(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 September 2005 (01.09.2005)

PCT

(10) International Publication Number
WO 2005/080901 A1

(51) International Patent Classification[7]: F28D 9/02

(21) International Application Number: PCT/KR2005/000467

(22) International Filing Date: 21 February 2005 (21.02.2005)

(25) Filing Language: Korean

(26) Publication Language: English

(30) Priority Data:
20-2004-0004770 24 February 2004 (24.02.2004) KR
10-2004-0012091 24 February 2004 (24.02.2004) KR
10-2004-0068668 30 August 2004 (30.08.2004) KR

(71) Applicant (*for all designated States except US*): **Spec Co., Ltd** [KR/KR]; 1695-5 Sinil-Dong, Daedeok-Gu, Daejeon-City 306-230 (KR).

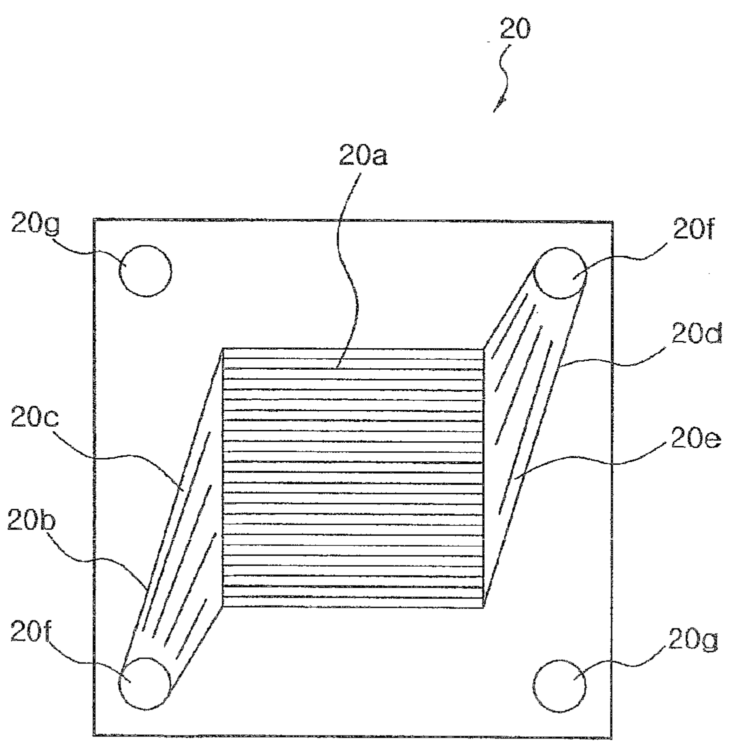
(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **CHOI, Young-Jong** [KR/KR]; 152-1 Sinseong-Dong, Yuseong-Gu, Daejeon-City 305-805 (KR). **LEE, June-Ho** [KR/KR]; Room 201, 206-2 Bongsan-Dong, Yuseong-Gu, Daejeon-City 305-506 (KR). **LEE, Sang-Hee** [KR/KR]; 102-1306 Parangsae Apartment, Dunsan-Dong, Seo-Gu, Daejeon-City 302-120 (KR). **HONG, Hwan-Pyo** [KR/KR]; 1104 Goldenriver, 141-28 Sintanjin-Dong, Daedeok-Gu, Daejeon-City 306-815 (KR). **CHOI, Min-Soo** [KR/KR]; 104-404 Kangbyeon Apartment, Mannyeon-Dong, Seo-Gu, Daejeon-City 302-741 (KR). **SOHN, Taek-Jun** [KR/KR]; 304 Jinbuilra, 296-5 Jeonmin-Dong, Daejeon-City 305-810 (KR). **LEE, Sung-Bae** [KR/KR]; 303 Ilsimhouse, 1221 Galma-Dong, Seo-Gu, Daejeon-City 302-170 (KR). **SONG, Ki-Youn** [KR/KR]; 406-126 Sambu Apartment, Taepyeong-Dong, Jung-Gu, Daejeon-City 301-150 (KR).

(74) Agents: **KWON, Oh-Sig** et al.; 401 Jooeun Leaderstel, 921 Dunsan-Dong, Seo-Gu, Daejeon-City 302-828 (KR).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM,

[Continued on next page]

(54) Title: MICRO HEAT EXCHANGER FOR FUEL CELL AND MANUFACTURING METHOD THEREOF



(57) Abstract: The present invention relates to a micro heat exchanger used for a fuel cell, etc., and a method of manufacturing the same. The micro heat exchanger of the invention comprises: a heat exchanging portion including a plurality of metal plates stacked and bonded to another, the metal plate having a plurality of metal plates stacked and bonded to one another, the metal plate having a plurality of micro channels formed in parallel on the metal plate for flowing a first fluid, a supply channel and a discharge channel for supplying and discharging a fluid to an from each micro channel. A first connection hole connected to the supply channel and the discharge channel respectively And formed on the metal plate in such a way as to pass through, and a second connection hole for supply and discharging a second fluid; and a manifold including a fixing plate bonded symmetrically to upper and lower sides of the heat-exchanging portion and a pipe formed in the fixing plate in such a way to pass through the fixing plate so as to be fluid-communicatively connected with the first connection hole and the second connection hole such that the first and second fluid are supplied and discharged respectively. The bonding between the metal plates, the heat-exchanging portion and the fixing plates is performed by inserting a bonding Thin plate in between and carrying out a brazing process.

WO 2005/080901 A1

AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MICRO HEAT EXCHANGER FOR FUEL CELL AND MANUFACURING METHOD THEREOF

Technical Field

The present invention relates to a micro heat exchanger used for a fuel cell or the like, more specifically to a micro heat exchanger and a method of manufacturing the same, in which a metal plate having a micro channel formed therein and a bonding thin plate are alternately stacked and bonded through a brazing process.

Background Art

In general, a heat transfer is an energy transmission more actively occurred between areas having different temperatures, in particular, their boundary in between. The heat transfer includes conduction by which a heat is transferred from a high temperature area to a low temperature area without a mass transfer, convection by which a heat is transmitted through a fluid transfer, and radiation in which atoms excited by heat emits electromagnetic waves.

Among them, the convection is defined as a heat transfer between a fluid and a solid, and has been used in the industries. In particular, a forcible convection, for example, a heat-exchange between the outer and the inner side of a tube is considered as a basic concept of heat exchange in heat-exchangers.

In the industrial on-sites, application of heat-exchangers are closely related to technical fields necessitating precision and super-miniaturization such electronic parts and materials in the information telecommunication technology associated with generation of high heat. The heat generation of an electronic part seriously affects the performance of

the entire system including the electronic part. Thus, its miniaturization has been required in order to mount a heat exchanger and consequently a micro-scaled heat exchanger has been proposed and developed.

It is known that this micro heat exchanger is applicable to a fuel cell, a chemical reaction involved in the petroleum industry, a cooling of medicine equipment, a nuclear generation, an a cooling of electronic equipment of airplanes, a cooling for a high heated-up laser, a seawater evaporation tube of a flesh-water manufacturing facility, or the like.

In particular, as the fuel cell has been widely used as a power supply for a notebook computer, the size of a heat exchanger adopted in the fuel cell keeps is being miniaturized more and more. However, the size and performance of fuel cell is also deteriorated due to a decrease in the heat-exchanging performance resulted from its miniaturization.

Most of the heat exchangers including the above micro heat exchanger are operated based on a forcible convection of fluid. The micro heat exchanger is applied to a fuel cell system and a process for manufacturing medical supplies. The micro heat exchanger is fabricated by stacking a series of metal plates, in each of which a micro channel is formed in parallel along one direction. A fluid is transferred along each micro channel, and thus the wall of the micro channel directs, guides, and forces the moving direction of the fluid.

As described above, in the micro heat exchanger using forcible/active fluid transfer, it is of importance to design a micro channel capable of forcing and guiding the fluid movement. In general, the micro channel is formed by a milling process using a micro-machining technology. The reason for importance of micro channel design is that the miniaturization of device results in difficulties in testing and measurement. For example, it is difficult to measure and control the flow rate and temperature of fluid within

the micro channel, in particular, the pressure and temperature exerted on the entire device and each micro channel.

In order to advance this measurement and control technology, the manufacturing of micro heat exchanger, in particular, the pressing and bonding of metal plates having micro channels formed therein is of great importance.

In the manufacturing technology of a micro exchanger, it is well known that a micro channel is formed on the metal plate, which is then press-bonded to each other, and in particular, this process allows for securing a good pressure resistance and heat resistance against the pressure and temperature exerted to each micro channel.

In the manufacturing of a conventional micro heat exchanger, the press-bonding technique of each metal plate with micro channels formed therein employs various technologies, for example, a laser bonding where the rim of stacked metal plates is bonded by means of a laser as a heating source, or a diffusion bonding where each metal plate is pressed at several hundreds degrees after a soldering material is coated, vapor-deposited, or electroplated on the metal plate, or without any solder material.

In addition, in the heat exchanger, the pipe for a fluid inlet port and outlet port and the manifold formed of a fixing plate is fabricated by welding the pipe to the fixing plate and bonding them to each other using the above-mentioned laser welding or diffusion bonding technologies.

The micro channel of each metal plate is a relatively depressed portion. In addition, this depression causes formation of a wall portion relatively protruded. This wall portion, which partitions each micro channel, is not bonded separately in case where the conventional bonding technologies are used for manufacturing a micro heat exchanger. Thus, the resultant micro heat exchanger embraces problems that the micro channel cannot endure the high temperature and high pressure exerted thereto.

In addition, when the conventional bonding technology is used, in particular, a separate electrochemical plating process is to be added, and also the high temperature pressing process needs a long period of time, so that it reduces its production efficiency and thus is not suitable for mass production. Thus, its manufacturing cost is increased and it cannot be universally applied to the whole industries of concern.

Similarly, the fabrication of the manifold requires strict working conditions, for example, the welding process must be carried out one by one and a careful attention must be paid for a complete sealing.

As described above, in the conventional technique for manufacturing a micro heat exchanger, during the bonding process of the metal plates having micro channels formed therein, the production efficiency is decreased and the heat resistance and pressure resistance of the micro heat exchanger are degraded. In addition, during the bonding of the manifold, the production efficiency is lowered, due to its overly strict working conditions.

Furthermore, as shown in FIG. 1, an insulation layer 1200 is filled between a casing 110 and a micro heat exchanger 1000 inside the casing 1100. The insulation layer 1200 is formed, for example, of ceramic wool. Thus, the exchanged heat generated from the micro heat exchanger 1000 is prevented from being transmitted to the casing 1100. In this way, the case 1100 inserting process and the insulation layer 1200 forming process are necessitated.

Accordingly, since the separate casing 1100 must be provided and the insulation layer 1200 must be formed, the manufacturing cost of the heat exchanger cannot be easily reduced. The above-mentioned insulation layer forming process is likely to lead to defective products and thus a number of the completed micro heat exchangers 1000 are inevitably waste-disposed, thereby increasing the manufacturing cost therefor.

In addition, the volume thereof is increased due to the above separate processes,

and in order to reduce its volume, the micro heat exchanger must be made smaller or the insulation layer 1200 must be made thinner, or the thickness of the casing 1100 must be made thinner, thereby decreasing the insulation efficiency and thus reducing significantly the heat exchanging efficiency thereof.

Furthermore, the weight thereof, along with the volume, is also increased, and the radiation heat emitted to the outside of the casing 1100 cannot be blocked basically. Thus, its handing is difficult and the radiation heat is inevitably transferred to the external devices, thereby significantly deteriorating the durability of devices.

Disclosure of Invention

According to one aspect of the invention, there is provided a micro heat exchanger including: a heat exchanging portion including a plurality of metal plates stacked and bonded to one another, the metal plate having a plurality of micro channels formed in parallel on the metal plate for flowing a first fluid, a supply channel and a discharge channel for supplying and discharging a fluid to and from each micro channel, a first connection hole connected to the supply channel and the discharge channel respectively and formed on the metal plate in such a way as to pass through, and a second connection hole for supply and discharging a second fluid; and a manifold including a fixing plate bonded symmetrically to upper and lower sides of the heat-exchanging portion and a pipe formed on the fixing plate in such a way as to pass through the fixing plate so as to be fluid-communicatively connected with the first connection hole and the second connection hole such that the first and second fluid are supplied and discharged respectively, wherein the bonding between the metal plates, the heat-exchanging portion and the fixing plate is performed by inserting a bonding thin plate in between and carrying out a brazing process.

In addition, the heat-exchanging portion is formed through an alternate stacking and bonding in such a manner that the first connection hole through the metal plate and the second connection hole through the adjacent metal plate are fluid-communicated with each other and the micro channels on the neighboring metal plates are crossed at a certain desired angle. The supply channel and the discharge channel further includes a distribution channel formed on the metal plate so as to be branched off and flowed together correspondingly to the micro channel.

The heat-exchanging portion is further provided with an insulation space formed by stacking the metal plates, which are further provided with one or more insulation hole formed in such a way as to pass through a desired area of the periphery of the micro channel. An insulation panel is inserted between the manifold and the heat-exchanging portion and bonded through a brazing process, the insulation panel including a through-hole fluid-communicated with the pipe of each manifold. The insulation panel is provided with one or more depressions on the micro channel forming direction. The insulation space or the depression is vacuumed by means of a vacuuming process during the brazing bonding process.

In addition, the heat exchanger of the invention may further comprises one or more vacuum port passing through integrally the insulation panel and another manifold stacked and combined therewith so as to be fluid-communicated with the depression and the insulation space.

According to another aspect of the invention, there is provided a method of manufacturing a micro heat exchanger. The method comprises steps of: (a) preparing a metal plate having a fluid supply channel and a fluid discharge channel, a plurality of parallel micro channels, and first and second connection holes connected respectively with the supply channel and the discharge channel; (b) forming a heat-exchanging portion by

stacking and bonding the metal plates with a bonding thin plate inserted in between, the micro channel facing one direction; (c) forming each manifold to be symmetrically bonded to upper and lower sides of the heat-exchanging portion, the manifold having a fixing plate to which each pipe is temporarily bonded so as to be fluid-communicated with the first and second connection holes; (d) coating a paste bonding agent near the connection area of each pipe to each fixing plate; (e) forming an assembly by assembling the heat-exchanging portion, each fixing plate and each manifold between a fixing jig and a mobile jig moving relative to the fixing jig, correspondingly to the fluid supply and discharge path, and placing a relatively small load weight on top of the mobile jig so as to exert a uniform load to the metal plate of the heat-exchanging portion; (f) placing each assembly in a brazing furnace, and heating the assembly above the melting temperature of the bonding thin plate and the bonding agent to thereby perform a bonding; and (g) removing the fixing jig, the mobile jig and the load weight after taking the assembly out of the brazing furnace.

The step (b) may further comprise a step of alternately stacking the metal plates in such a manner that a first connection hole of the metal plate is fluid-communicatively connected with a second connection hole of a neighboring metal plate and a micro channel of the metal plate is crossed with the micro channel of the neighboring metal plate at a certain desired angle.

The step (a) may further comprise a step of forming a distribution channel on the supply channel and the discharge channel such that the micro channel and the first connection hole are fluid-communicated with each other, and branched off and flowed together respectively.

The step (b) may further comprise a step of disposing the metal plate in such as a way that the micro channel containing face thereof faces downwards.

The step (a) may further comprise a step of punching an insulation hole of same shape in a same place.

The step (b) may further comprise a step of stacking an insulation panel between the manifold and the metal plate, and inserting and stacking a bonding thin plate in between.

Brief Description of Drawings

Further objects and advantages of the invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view showing the internal structure of a conventional heat exchanger;

FIGS. 2 to 10 illustrate a process for fabricating a micro heat exchanger according to one embodiment of the invention;

FIG. 11 is an exploded perspective view showing a micro heat exchanger according to one embodiment of the invention;

FIGS. 12 to 20 illustrate a process for fabricating a micro heat exchanger according to another embodiment of the invention;

FIG. 21 is an exploded perspective view showing a micro heat exchanger according to another embodiment of the invention;

FIG. 22 is a photograph showing a vertical cross-section of a bonded laminated structure in the micro heat exchanger fabricated according to the invention;

FIG. 23 is an enlarged photograph showing a micro channel in FIG. 22;

FIG. 24 is an exploded cross-section showing a micro heat exchanger according to a further embodiment of the invention;

FIGS. 25 and 26 are plan views showing respectively a modified embodiment of a metal plate;

FIG. 30 is a perspective view showing an insulation panel according to one embodiment of the invention;

FIGS. 31 and 31 are perspective views showing respectively a modified example of FIG. 30;

FIG. 33 is an exploded perspective view showing a heat exchanger according to another embodiment of the invention; and

FIG. 34 is a flow chart explaining a process for fabricating a heat exchanger according to another embodiment of the invention.

Best Mode for Carrying Out the Invention

The preferred embodiments of the present invention will be hereafter described in detail with reference to the accompanying drawings.

[First embodiment]

FIGS. 2 to 10 illustrate the process for fabricating a micro heat exchanger according to an embodiment of the invention.

In the process of the invention, each metal plate 20 having a micro channel 20a formed therein is laminated/inverted/arranged/assembled/bonded between manifolds 30 and 70 to fabricate a heat exchanger 200. In particular, a process for alternately laminating each metal plate 20 and a bonding thin plate 220 is included, and this process provides a method where all the boundary area of each micro channel 20a is participated in a bonding process. At this time, the metal plates 20 are laminated and bonded in such a way that the micro channels 20a of neighboring metal plates 20 are crossed at a certain angle so that each fluid of different temperature can be supplied and discharged alternately. In addition,

the metal plate 20 is disposed such that the face thereof having the micro channel 20a formed thereon faces downward, and then a brazing process is carried out. Accordingly, this provides a practical merit that the melt of the bonding thin plate 220 is prevented from flowing into the micro channel 20a.

As illustrated in FIGS. 2 to 10, first, a common mechanical processing such as a press forming or a milling machining, or a special process such as a photo-etching process, a precision casting, a metal injection molding is performed on each metal plate 20, to thereby obtain micro channels 20a formed along one direction in parallel to each other. The micro channel 20a has a width and/or a depth of no more than 1mm.

Here, a rectangular area in the center of the metal plate 20 is selected as a forming area of the micro channel 20a. In the selected area are formed parallel micro channels 20a and four through-holes are formed around the area where the micro channel 20a is formed. The position of each through-hole corresponds to each corner of the metal plate 20 and the through-holes are formed symmetrically. The through-holes constitute connection holes 20f and 20g, to which each pipe 50, 60, 90, 100 forming each manifold 30, 70 is connected. In addition, when the metal plate 20 is laminated and bonded, the through-holes form a passageway, through which a low temperature or high temperature fluid is transferred to be supplied to and be discharged from each micro channel 20a. Among these connection holes 20f and 20g, the ones that are diagonally opposed and connected with the micro channel 20a constitute a first connection hole 20f, and the ones that are diagonally opposed, but not connected with the micro channel, constitute a second connection hole 20g. The first connection hole 20f and the second connection hole 20g are configured such that a first fluid and a second fluid are supplied thereto and discharged therefrom respectively.

At this time, a supply channel 20b and a discharge channel 20d are formed in such a way as to be expanded gradually towards the micro channel-forming area starting from

the first connection hole 20f and be fluid-communicatively connected with the micro channel 20a. Here, it is preferable that a supply distribution channel 20c and a discharge distribution channel 20e are formed so as to correspond to the micro channels 20a such that the fluid can be branched out to each micro channel from the supply channel 20b or conversed into the discharge channel 20d from the micro channel 20a (S1100).

Accordingly, a metal plate 20 is prepared, as illustrated in FIG. 2.

In addition, plural metal plates 20 prepared as above are laminated, alternately with a bonding thin plate 220, in such a manner that micro channels of the neighboring metal plates are crossed with each other at a certain angle so that each fluid having a different temperature can be alternately supplied and discharged. The bonding thin plate 220 serves as a bonding medium, which is melted when carrying out a bonding operation in a brazing furnace 300. As a material for the bonding thin plate 220, silicon ally is used when an aluminum metal plate 20 is used, silver or silver alloy is used when a copper metal plate 20 is used, and nickel alloy or pure copper is used when a stainless steel or heat-resistant alloy plate 20 is used. In addition, the thickness of the metal plate 20 is preferred to be no more than 0.1mm, more preferably in a range of 0.025~0.05mm, in order to prevent the micro channel from being blocked during the brazing-bonding operation.

First, a metal plate 20 is stacked on the bonding thin plate 220 having the same size as that of the metal plate 20 in such a way as to the face having a micro channel 20a formed therein is faced upward so that the forming direction of the micro channel 20a can be viewed from above. Next, another metal plate 20 is stacked thereon alternately such that the micro channel forming direction thereof is crossed with that of the right under metal plate 20. At this time, similarly, it is disposed in such a way that the micro channel 20a is faced upwardly. Then, the first connection hole 20f and the second connection hole

20g are disposed respectively in same positions through the metal plates 20 having a same forming direction of micro channel 20a. Then, after a desired number of metal plates 20 and the bonding thin plates 220 are laminated, a bonding thin pate 220 is disposed for bonding with a manifold 30, 70. Accordingly, a heat exchanging portion 10, in which a metal plate 20 and a bonding thin plate 220 are stacked one upon another, formed. Thus, in the completed product, when a fluid flows through the connection holes 20f and 20g, the fluid is supplied into the supply channel 20 and the micro channel 20a through the first connection hole 20f and discharged through the discharge channel 20d and the first connection hole 20f, which is diagonally placed.

If the fluid is in-flown into the second connection hole 20g, it is passed through and reaches the lowest first connection hole 20f to thereby flow to the corresponding micro channel. That is, an alternate supply and discharge configuration is prepared. Consequently, considering that a respective fluid having a different temperature is provided to the connection holes facing the above-described connection holes 20f and 20g, i.e., respectively to the first connection hole 20f and the second connection hole 20g in one metal plate 20, a high temperature fluid and a low temperature fluid are alternately supplied and discharged and thus a heat exchange between neighboring metal plates 20 can be performed (S1200). This configuration of the present invention is achieved by stacking the metal plates alternately such that the micro channel 20a forming directions are crossed to each other.

In the above-described stacking method, the bonding thin plate 220 is faced to one whole surface of the metal plate 20 and thus the boundary area of the micro channel 20a can be fusion-bonded when the bonding thin plate 220 is melted during subsequent brazing bonding process.

In this way, after the metal plate 20 and the bonding thin plate 220 are alternately

laminated, based on the micro channel forming directions between the metal plates 20, the resultant heat exchanging portion 10 having each metal plate 20 and each bonding thin plate 220 stacked one upon another is disposed so as to be inverted. Then, the metal plate 20 is placed with the micro channel facing downwards. Thus, the melt of the bonding thin plate 220 is prevented from flowing to the micro channel 20a during the subsequent brazing bonding process (S1210).

Then, a first manifold 30 and a second manifold 70 are fabricated. First, a first fixing plate 40 and a second fixing plate 80 are prepared so as to having the same size as the metal plate 20 and a thickness relatively thicker than the metal plate. Each fixing plate 40, 80 has two holes formed at the positions corresponding to the first connection hole 20f and the second connection hole 20g of the metal plate 20. To each of these holes is bonded a first pipe 50, a second pipe 60, a third pipe 90 and a fourth pipe 100 by means of a spot welding, thereby completing each manifold 30, 70 having a structure corresponding to the duct structure formed by the first connection hole 20f and the second connection hole 20g through the lamination of metal plates 20 (S1300).

Thereafter, a bonding agent 230 is coated around the connecting area between the fixing plates 40 and 80 and the pipes 50, 60, 90, 100. The bonding agent is formed of the same material as the bonding thin plate 220 and has a paste form (S1400).

At this time, the previously prepared heat exchanging portion 10, in which the metal plate 20 and the bonding thin plate 220 are stacked, tends to disturb its laminated structure when inverted. Therefore, the heat-exchanging portion 10 needs to be restrained for arrangement. For this purpose, an aligning member 240 is tightly attached to the corner area of the metal plate since the metal plate 20 and the bonding thin plate 220 has a rectangular shape. The aligning member 240 is a rod structure, in which one side is depressed such that the corners of the metal plate 20 and the bonding thin plate 220 are

inserted thereto and closely contacted therewith. The aligning member 240 is formed of the same material as the metal plate 20, or a ceramic material. At this time, in case of the same material, preferably, the surface of the aligning member 240 is coated with a liquid containing ceramics beforehand so as not to stick to the metal plate 20.

In addition, preferably, the aligning member 240 is designed such that the load in the gravitational direction, i.e., in the height of the heat-exchanging portion 10 is larger than the static friction force thereof, thus preventing the metal plate 20 from being buckled due to heat expansion thereof during the brazing bonding process. In this way, each aligning member 240 is pressurized against each corner of the heat-exchanging portion 10, to thereby achieve an easy alignment (S1410).

Further, a fixing jig 290 and a mobile jig 270 are provided in order to assisting in the assembling of each manifold 30 and 70 and the heat-exchanging portion 10. The mobile jig 270 and the fixing jig 290 are disposed at the upper and lower sides of the manifolds 30 and 70 and the heat-exchanging portion 10 to be assembled to each other. The jigs 270 and 290 are formed of a thick plate material and has holes formed so as not to be interfered with each pipe 50, 60, 90, 100 of each manifold, which is to be positioned at the upper and lower sides of the inverted/aligned heat-exchanging portion 10.

First, the fixing jig 290 is placed on a floor, and the first manifold 30 is inverted thereon and the first pipe 50 and the second pipe 60 are inserted into the holes of the fixing jig 290. Then, thereon is placed the heat-exchanging portion 10, together with the aligning member 240. Here, the aligning member 240 aligns the heat-exchanging portion 10, together with the first fixing plate 40 of the first manifold 30, which is disposed a the lower side of each aligning member 240. Then, the mobile jig 270 is placed thereon, and the third pipe 90 and the fourth pipe 100 are inserted into each hole of the mobile jig 270.

Here, at both sides of the fixing jig 290 is disposed a guide 280 fixed along the

height thereof. Each guide 280 is formed at a position corresponding to both sides of the mobile jig 270, and is assembled in such a way as to be inserted into a hole formed relatively larger than each guide 280. Then, a load weight is placed on top of the mobile jig 270. The load weight 60 is a metal weight capable of exerting a pressure of above $10g/cm^2$, preferably around $50\sim150g/cm^2$, considering the thickness of the metal plate 20. Thus, the assembly 270 can be brazing-bonded under a certain pressure. At this time, since the plate-like mobile jig 270 having a relatively large surface area is placed between the load weight 260 and the assembly 210, the pressure can be uniformly exerted over the whole assembly 210, while the mobile jig 270 moves downwardly along the guide 280.

In this way, the assembly 210 to be put in the brazing furnace 300 is obtained.

The resultant plural assemblies 210 are put in a brazing furnace 300. At this time, inside the brazing furnace 300 may be at vacuum, in an inert gas atmosphere, or a reduction gas atmosphere. When the brazing furnace 300 is operated to thereby increase the temperature to above the melting temperature of the bonding agent 230 of paste coated between the metal plate 20 and the bonding thin plate 220, the metal 20 and the fixing plate 40, 80 are bonded, and the fixing plate 40, 80 and the pipe are bonded. At this time, since the bonding thin plate 220 is tightly contacted with the whole surface of the metal plate 20, the bonding is occurred in the boundary area of the micro channels 20a. In addition, the heat-exchanging portion 10 is bonded in such a way that the micro channel-formed face of the metal plate 20 is faced downwardly, and thus the melt of the bonding thin plate 220 is not introduced into the micro channel 20a.

Consequently, the metal plates 20 are bonded to each other such that each boundary area of the micro channel on the neighboring plates is closed disposed, so as to form a flow passageway by the micro channels 20a, thereby completing a micro heat exchanger 200 (S1600).

After the brazing bonding process, the assembly is taken out of the brazing furnace 300. Then, the fixing jig 290, the mobile jig 270, the aligning member 240 and the load weight 260 are removed, and if necessary, a post treating process is applied to remove remaining melt, protruded onto the surface (S1700).

FIG. 11 is an exploded perspective view of a micro heat exchanger 200 manufactured according to an embodiment of the invention. As shown in FIG. 11, the micro heat exchanger 200 fabricated through the above-described method comprises a heat-exchanging portion 10 including a plurality of metal plates 20 which are laminated/bonded so as to cross the micro channel-forming directions relative to one another, and a first and second manifold 30, 70 disposed at both sides of the heat-exchanging portion 10 in the stacking direction of the metal plate 20.

At this time, as the metal plates 20 are alternately stacked based on the micro channel forming direction, the first connection hole 20f and the second connection hole 20g form one passageway and this passageway come to be fluid-communicated with each pipe 50, 60, 90, 100 of the each manifold 30, 70. Therefore, when a fluid is introduced through each pipe 50, 60, 90, 100, the fluid is supplied to each micro channel 20a on the supply channel 20b formed from each connection holes 20f, 20g to the micro channel 20a and discharged through the discharge channel 20d. In addition, since the metal plates 20 are combined such that each micro channel forming direction is crossed with each other, along an alternate metal plate 20 is circulated a fluid having a same temperature.

Here, the specific fluid circulation path will be explained. First, when a fluid, for example, a high temperature fluid, is flown into the first metal plate 20 adjacent the first manifold 30 through the first pipe 50 of the first manifold 30, the high temperature fluid is provided through a first connection hole 20f of the metal plat 20 fluid-communicated with the first pipe 50, and then flows on the supply channel 20b and the supply distribution

channel 20c branched from the supply channel 20 to consequently flow into the concerned micro channel 20a.

This fluid flows through the micro channel 20a and is discharged through the discharge channel 20d. At this time, if a low temperature is provided through a second pipe 60 to the second connection hole 20g, which is diagonally opposed to the first connection hole 20f to which the high temperature fluid is provided through the metal plate 20 adjacent to the first fixing plate 40, the low temperature fluid comes to flow the first connection hole 20f, the supply channel 20b, the micro channel 20a and the discharge channel through the right behind metal plate 20, thus providing a thermal relationship between the neighboring metal plates.

In addition, the second manifold 70 is placed in opposite relation to the first manifold, and the third pipe 90 and the fourth pipe 100 thereof are connected respectively to the first connection hole 20f and the second connection hole 20g, which is in opposite to the first connection hole 20f and the second connection hole 20g to which the first pipe 50 and the second pipe 60. Thus, the high temperature fluid of the first pipe 50 is discharged through the third pipe 90 via the circulation path as described above, and the low temperature of the second pipe 60 is discharged through the fourth pipe 100. At this time, the fluids are provided in different directions, which can be designed, depending on application of the micro heat exchanger according to the present invention.

[Second embodiment]

FIGS. 12 to 20 show a process for fabricating a micro heat exchanger according to another embodiment of the invention. As shown in FIGS. 12 to 20, an alignment pin 250 is used for forcibly restraining and aligning the heat-exchanging portion 10.

First, a micro channel 20a is formed in parallel on the central area, and two first connection holes 20f and two second connection holes 20g are formed by drilling. A

supply channel 20b and a discharge channel 20d are formed in such a way as to be expanded from the diagonally positioned two first connection hole 20f to a micro channel forming area. At this time, a supply distribution channel 20c and a discharge distribution channel 20e are branched respectively from the supply channel 10b and the discharge channel 20d, to thereby enable a smooth flow of supply or discharge fluid.

In addition, as an alignment hole, four holes are formed, one near each side of the metal plate and at the center thereof. The alignment hole 20h has a smaller size relative to the connection holes 20f, 20g. Each alignment hole 20h is used for aligning a heat-exchanging portion 10 using an alignment pin 250 (S2100).

Thereafter, when laminating, the metal plate 20 and the bonding thin plate 220 are alternately stacked in such a way that the micro channel containing face of the metal plate 20 faces upwardly in order to recognize the micro channel forming direction, thereby forming a heat-exchanging portion 10. Along with the alternate stacking of the metal plate 20 and the bonding thin plate 220, they are laminated such that the micro channel 20a forming directions are also alternated. That is, in two neighboring metal plates 20 with a bonding thin plate 220 placed in between, the metal plates are stacked repeatedly so as to cross each micro channel 20a with each other. Accordingly, every other metal plate 20 has a same micro channel 20a forming direction, and two neighboring metal plates with the bonding thin plate 220 in between have micro channels 20a crossing each other. At this time, on top and bottom of the heat-exchanging portion 10 is disposed a bonding thin plate 220 according to the stacking order, so that each manifold 30, 70 can be bonded at both sides of the stacking direction (S2200).

In this stacking structure, when brazing bonding, the melt of the bonding thin plate 220 is very likely to flow toward the inside of the micro channel 20a. Thus, in order to avoid this phenomenon, the heat-exchanging portion 10 is constructed such that the micro

channel 20a faces downwardly (S2210).

Next, each manifold 30, 70 is fabricated. First, a first fixing plate 40 and a second fixing plate 80 thicker than the metal plate 20 are prepared, and in each fixing plate 40, 80 are formed four holes at positions corresponding to each connection hole 20f, 20g. A fixing plate alignment pin 250 is formed at positions corresponding to the alignment hole 20h of the metal plate 20 and so as to have a size corresponding thereto. Among the holes formed corresponding to each connection hole 20f, 20g, two holes disposed along a rim thereof are connected with a first pipe 50 and a second pipe 60, and a third pipe 90 and a fourth pipe 100 respectively using a spot welding, to thereby fabricate the first manifold 30 and the second manifold 70 (S2300).

Thereafter, a bonding agent 230 is coated around the connection area between each pipe 50, 60, 90,100 and each fixing plate 40, 80. The bonding agent 230 is formed of the same material as the bonding thin plate 220 and has a paste form.

At this time, each metal plate 20 forming the heat-exchanging portion 10 does not have a connective relation to align the stacking structure. Thus, into the above-formed alignment hole 20h of each metal plate 20 is inserted the alignment pin 250 continuously, to thereby align the metal plates 20 (S2410).

In addition, in order to assemble the heat-exchanging portion 10 and each manifold 30, 70, an auxiliary member, i.e., a mobile jig 270 and a fixing jig 290 are used. The mobile jig 270 and the fixing jig 290 have the form of a thick plate and each has a hole formed so as to insert each pipe 50, 60, 90, 100 of each manifold 30, 70. At both sides of the fixing jig 290 is fixed a rod-shape guide 280, along which the mobile jig 270 is guided upwards and downwards.

First, the first pipe 50 and the second pipe 60 of the first manifold 30 are inserted into and fixed to the fixing jig 290. The heat-exchanging portion 10 is placed and aligned

thereon such that the micro channel 20a faces downwards. At this time, each alignment pin 250 is inserted into the first fixing plate alignment hole 40a of the first fixing plate so as to be aligned together with the heat-exchanging portion 10. In addition, the second manifold 70 is placed on top of the heat-exchanging portion 10. At this time, each alignment pin 20 is inserted into the second fixing plate alignment hole 80a of the second fixing plate 80. Accordingly, each manifold 30, 70 and the heat-exchanging portion 10 are assembled to each other.

Then, the mobile jig 270 is placed on top of the second manifold 70, and the third pipe 90 and the fourth pipe 100 of the second manifold 70 are inserted. Accordingly, in the resultant assembly 210, the pressure of the load weight 260 is exerted uniformly along the height of the heat-exchanging portion 10 through the mobile jig 270 (S2500).

A plurality of above assemblies 210 is fabricated and put inside a brazing furnace 300, which is heated above the melting temperature of the bonding thin plate 220 and the bonding agent 230. Then, each metal plate 20 is bonded such that the boundary area of the micro channel 20a is bonded to the other surface of adjacent metal plate 20 to thereby form a flow passageway. Each pipe 50, 60, 90, 100 is bonded to each fixing plate 40, 80 and also each manifold 30, 70 is bonded to the heat-exchanging portion 10. Consequently, a micro heat exchanger 200 is completed (S2600).

Then, the fixing jig 290, the mobile jig270, the load weight 260 and the alignment pin 250 are removed from the completed micro heat exchanger 200, and the remaining melt protruded outside is removed as a finishing process (S2700).

FIG. 21 is an exploded perspective view of a micro heat exchanger fabricated according to another embodiment of the invention. As illustrated in FIG. 21, the micro heat exchanger 200 of this embodiment is structured in such a way as to alternately disposing each metal plate 20, based on the micro channel 20a forming direction, such that

a fluid having a different temperature can flow through each micro channel 20a of each metal plate 20 in neighboring metal plates 20.

For this purpose, the heat exchanger 200 includes a heat-exchanging portion 10 in which each metal plate 20 is stacked, and a first manifold 30 and a second manifold 70 disposed at both sides of the heat-exchanging portion 10 and supplying/discharging fluids having different temperatures, thereby performing a heat exchange between them.

Here, in the heat-exchanging portion 10, each metal plate 20 is stacked/bonded through a brazing process. When each fluid flows through the micro channel 20a in each metal plate 20, a heat exchange is occurred in the heat-exchanging portion 10.

As shown in FIG. 11, this metal plate 20 includes a plurality of micro channels 20a formed in parallel on the center of one face thereof and having generally a rectangular shape, and a supply channel 20b and a discharge channel 20d connected with the micro channel 20a. In addition, a supply distribution channel 20a and a discharge distribution channel 20e are formed in such way to be branched from the supply channel 20b and the discharge channel 20d.

Two first connection holes 20f are formed at the starting point of the supply channel 20b and the discharge channel 20d. The first connection holes 20f pass through the metal plate 20 and are diagonally opposed. In addition, two second connection holes 20g are diagonally formed at positions facing each first connection hole 20f. The second connection hole 20g passes through the metal plate 20 and has no structural relationship with the flowing path of the corresponding micro channel 20a.

Here, the metal plate 20 is disposed alternately with neighboring plate, based on the micro channel 20a forming direction. Thus, the first connection hole 20f is connected with the second connection hole 20g through the behind metal plate 20 to thereby form a passageway.

At this time, the first connection hole 20f is fluid-communicated with the corresponding micro-channel 20a, and the second connection hole 20g has no connection with the corresponding micro channel 20a and thus the fluid flow the first connection hole 20f only. In addition, considering the first connection hole 20f and the second connection hole 20g diagonally disposed, the provided fluid flows the supply channel 20b and the micro channel 20a and then discharged through the discharge channel 20d. Then, again the fluid is discharged through the first connection hole 20f diagonally placed, then passes through the second connection hole 20g behind thereof, and is supplied to the first connection hole 20f behind thereof. This flow pattern is repeated.

If fluids of different temperatures are provided respectively into the first connection hole 20f and the second connection hole 20g facing each other, then a different temperature fluid flows through the micro channel 20a in each metal plate 20 to thereby perform a heat exchange between the neighboring metal plates.

The first manifold 30, which is disposed at one side of the heat-exchanging portion 10, provides a fluid to each metal plate 20 constituting the heat-exchanging portion 10. The first manifold 30 includes a first fixing plate 40, and a first pipe 50 and a second pipe 60 disposed in parallel at one side of the first fixing plate 40 and fluid-communicated therewith.

At this time, the first fixing plate 40 is faced with and bonded to the first connection hole 20f and the second connection hole 20g of the front metal plate 20 so as to correspond to the first pipe 50 and the second pipe 60. Therefore, the first pipe 50 and the second pipe 60 are connected with the corresponding first connection hole 20f and second connection hole 20g, and thus by this connection structure a high temperature fluid and a low temperature fluid are provided to the heat-exchanging portion 10.

The first pipe 50 is connected to the first connection hole 20f, and thus if a high

temperature fluid is provided, the fluid flows through the supply channel 20b, a supply distribution channel 20c, a micro channel 20a, a discharge channel 20d, a discharge distribution channel 20e of the corresponding metal plate, and then, through the diagonally disposed first connection hole 20f, supplied to the behind other metal plate 20.

The micro channel 20a in this behind metal plate 20 is crossed with that of the front metal plate 20, and thus the front first connection hole 20f and the behind second connection hole 20g are fluid-communicated with each other. Therefore, the high temperature fluid does not flow the micro channel 20a on the behind metal plate 20, but directly is supplied to the first connection hole 20f of the behind metal plate 20 through the corresponding second connection hole 20g. Thus, the fluid is supplied and discharged alternately, conforming to the order previously mentioned.

The second pipe 60 is connected to the second connection hole 20g of the metal plate 20 adjacent to the first fixing plate 40. Through the second pipe 60, a fluid having a temperature different from the first pipe 50 is provided to the second connection hole 20g. For example, in case where a low temperature fluid is provided, the first connection hole 20f of other metal plate 20 is fluid-communicated backwards of this second connection hole 20g.

Thus, the low temperature fluid is not provided to the micro channel 20a of the metal plate 20 adjacent to the first fixing plate 40, but provided to the first connection hole 20f of the behind metal plate 20, and then flows the supply channel 20b, the supply distribution channel 20c, a micro channel 20a, a discharge channel 20d, a discharge distribution channel in the described order and subsequently supplied to the second connection hole 20g of the behind metal plate 20 through the diagonally placed first connection hole 20f. Thus, the low temperature fluid is supplied and discharged alternately.

The second manifold 70 is disposed at a position facing the first manifold 30 with the heat-exchanging portion 10 in between. The second manifold 70 includes a second fixing plate 80 bonded to a corresponding metal plate 20 and a third and fourth pipe 100 bonded/connected to the second fixing plate 80, in order to discharge the high temperature and low temperature fluids provided to the heat-exchanging portion 10 from the first manifold 30. The first and second pipes 50 and 60 are connected to the first connection hole 20f and the second connection hole 20g through the lower metal plate 20. Dissimilarly, the third pipe 90 and the fourth pipe 100 are connected to the first connection hole 20f and the second connection hole 20g through the upper metal plate 20.

FIG. 22 is a photograph showing a vertical cross-section of a bonded heat-exchanging portion 10 in the micro heat exchanger 200 fabricated according to the invention. FIG. 23 is an enlarged photograph showing a micro channel 23a in FIG. 22. As shown in FIGS. 22 and 23, a cross-section taken along the stacking direction of the heat-exchanging portion 10 is illustrated. It can be seen that the bonding thin plate 220 is melted/bonded to each face of the metal plate 20 through the brazing bonding process, and in particular the boundary area of the micro channels 20a is bonded.

Accordingly, each flow passageway comprised of a micro channel 20a and the other face of the metal plate 20 abutted thereto, i.e., the metal plate 20 is boned on the whole, excepting the area related to the fluid flow.

As described above, in the micro heat exchanger and the manufacturing method thereof according to the invention, each manifold 30, 70 may be disposed so as to have different positions of the pipes 50, 60, 90, 100 relative to the heat-exchanging portion 10, or the number of stacked metal plates 20 may be varied, depending on the design specification of applications.

In addition, the supply channel 20b and the discharge channel 20d is formed

towards each first connection hole 20f diagonally disposed with the micro channel forming area in between. In stead, however, the first connection hole 20f may be formed facing each other with the micro channel 20a placed in between and the supply channel 20b and the discharge channel 20d may be formed.

[Third embodiment]

FIG. 24 is an exploded cross-section of a heat exchanger according to the invention, and FIG. 25 is a plan view of a metal plate according to another embodiment of the invention. FIG. 30 is a perspective view of an insulation panel according to an embodiment of the invention.

Referring to FIGS. 24, 30, and 33, an insulation-type heat exchanger according to the invention a heat exchanger 10 where a plurality of metal plates 20 is alternately stacked perpendicularly to one another, two insulating panels 310, 320 stacked at both end of the heat-exchanging portion 10, and a first and second manifold 30, 70 stacked and rested on the insulation panels 310 and 320 respectively.

Here, in the heat-exchanging portion 10, a plurality of metal plates 20 is alternately stacked, and a bonding thin plate 220 is inserted between neighboring metal plates 20, which is bonded to each other through a brazing process. As shown in FIG. 25, an insulation hole 22 of certain desired shape is formed through the metal plate 20 of the invention and thus the insulation holes 22 form a desired insulation space 23 inside the heat-exchanging portion 10.

The shape of the insulation hole 22, which is formed through the metal plate, may include a circular shape, an elliptical shape, a triangular shape, an arcuate shape, or a combination thereof. As shown in FIG. 28, the insulation hole 22 may be formed in a trust pattern so as not to severely decrease the strength of the metal plate. Alternatively, as shown in FIG. 29, plural insulation holes may be formed in parallel or in series along the

peripheral area of the micro channel, such that the exchanged heat transferred from the micro channel is prevented from being transmitted to the rim area of the metal plate, thereby achieving an effective insulation through controlling the heat transmission passageway.

In particular, the bonding is carried out in a vacuum furnace so that the vacuum of the insulation space can be maintained, thereby further enhancing the insulation effect thereof.

In FIG. 25, a plurality of insulation holes 22 is formed through the metal plate so as to place near the connection hole 20f and the micro channel 20a, such that the exchanged heat can be prevented from being transmitted to the area near the micro channel 20a and the connection hole 20f.

In addition, the insulation panel 310, 320 is constructed as illustrated in FIG. 30. That is, in one face of the insulation panel 310 is provided a plurality of depressions 311 and a supporter 312 having a crusade form is provided in order to support the face abutted mutually with the metal plate 20 or the manifold 30, 70. The rear face of the insulation panel 310 has a flat surface, which is to be bonded with the metal plate 20 or the manifold 30, 70 through a brazing process.

As shown in FIG. 24, the insulation panel 310 is bonded with the first manifold 30 at the face having the depression 311 through a brazing process. The depression 311 containing face on the insulation panel 320 is bonded to the metal plate 20 provided at one end of the heat-exchanging portion 10 through a brazing process. The specific effect resulting from this connection structure will be hereinafter described.

Therefore, a waste heat, which is transferred to the peripheral area of the metal plate 20, can be avoided, thereby preventing reduction in the heat exchanging efficiency. Since it provides a good insulation effect without a casing 1100 and an insulation layer

1200, which is necessitated in the conventional technique, thereby enabling a simplification of manufacturing process and a reduction in the volume thereof. In particular, the metal plates used in the stacking are punched, thereby reducing the weight thereof, as compared with the conventional heat exchanger.

[Fourth embodiment]

FIGS. 25 to 29 are plan views showing various modifications of the metal plates, where an insulation hole 22 is formed in various places of the metal plate 20 in various shapes.

More specifically, FIGS. 25 and 27 illustrate an insulation hole 22 formed so as not to decrease the strength of the metal plate 20. FIGS. 28 and 29 show a metal plate capable of further improving the insulation efficiency thereof.

In particular, in the insulation holes 22 and a conduction portion 21 formed between the insulation holes 22 illustrated in FIGS. 28 and 29, the conduction heat generated from the exchanging heat must pass through the conduction portion 21 before being transferred toward the peripheral area of the metal plate 20. Thus, the surface area of the conduction area is preferred to be enlarged and the insulation hole 22 is disposed between the conduction portion 21, so that extremely small part of the exchanging heat is transmitted to the outer peripheral area of the metal plate 20, thereby increasing the heat exchanging efficiency significantly. Also, the outer area of the heat-exchanging portion 10 can be maintained at a lower temperature so that the heat exchanger of the invention can be touched without any risk of being burned, thereby enabling an easy handling of the heat exchange of the invention.

Preferably, the metal plate 20 shown in FIGS. 25 and 27 is suitable for a small-sized heat exchanger, which doe not necessitate a number of metal plates 20. The metal plates 20 shown in FIGS. 28 and 29 are suitable for a heat exchanger using a relatively

large number of metal plate 20, thereby compensating for the reduced strength by means of the bonding force of multiple metal plates 20.

[Fifth embodiment]

FIGS. 31 and 32 are perspective view showing modifications of FIG. 30. Here, the insulation panel 310, 320 is configured in such a way that each separate insulation space 23 is formed so as to be fluid-communicatively connected, so that vacuum can be easily and simply effected inside the insulation space 23.

Referring to FIG. 31, the insulation panel 310 is constructed such that the insulation space 23 partitioned as each separate space is fluid-communicated with each other when being brazed with the metal plate 20 placed at one end of the heat-exchanging portion 10. FIG. 32 has the same construction as the above-mentioned FIG. 30, but it is configured in such a manner that the supporter 312 between the depressions 311 has a cut groove 313 formed at desired positions thereof so as to having a desired shape, thereby enabling a fluid communication between the depressions 311 and thus a free air flow between the depressions 311.

Therefore, in the insulation panel 310, 320 having the construction shown in FIGS. 31 and 32, the inside of the insulation space 23 must be maintained in vacuum in order to improve the insulation efficiency. Thus, as shown in FIG. 31, a through-hole 314 is provided in a desired area of the insulation panel 310 having the depression 311, so that a vacuum tube or the like can be inserted through the through-hole after manufacturing or when in use, advantageously thereby maintaining an appropriate vacuum inside the insulation space 23.

[Sixth embodiment]

FIG. 33 is an exploded perspective view of a heat exchanger according of another embodiment of the invention. This embodiment adopts the insulation panel 310, 320 of the

fifth embodiment and the metal plate 20 of the fourth embodiment. A vacuum port 110 is provided in an area corresponding to the through-hole 314, which is provided through the insulation panel 310 among the first manifold 30, so that the plurality of insulation spaces 23 provided inside the heat-exchanging portion 10 can be vacuumed through a single vacuum port 110. Here, the vacuum port 110 may be formed in plural. In addition, a clamping means or a vacuum valve may be provided in the vacuum port so that additional vacuum can be effected, thereby maintaining an appropriate vacuum.

[Seventh embodiment]

FIG. 34 is a flow chart showing a process for manufacturing a heat exchanger according to the present invention.

Referring to FIG. 34, in the manufacturing process of the metal plate 20, which includes a micro channel 20a, a distribution channel 20e, the connection hole 20f, or the like, a step of punching an insulation hole 22 (S3100) is provided, and at the same time, the insulation panel 310, 320 and the manifold 30, 70 having the previously-mentioned construction are fabricated.

Thereafter, a cleansing/assembling step (S3200) is performed. In order to carry out a brazing bonding process, a plurality of metal plates 20, insulation panels 310, 320, bonding thin plates 220 are disposed between the above plural metal plates 20, between the heat-exchanging portion 10 and the insulation panel 310, 320, and between the manifold 30, 70 and the insulation panel 310, 320 and then stacked and assembled to each other.

Thereafter, the above-assembled heat exchanger is placed in a brazing furnace (not shown) and a bonding process (S3300) is performed under vacuum to thereby bond and combine the above assembly. Upon completion of bonding process (S3300), the completed heat exchanger is taken out of the brazing furnace (not shown) and cleaned and finished (S3400).

Here, the bonding process (S3300) is performed in the same manner as in the previously described prior invention. Through the stacking metal face described in the seventh embodiment and the vacuum port 110, vacuum is effected in the insulation space 23 partitioned inside the heat-exchanging portion 10 (Vacuum effecting step: S3310). As a heating step (S3320) is carried out, each element is firmly bonded and combined to each other through melting/wetting/solidifying of the bonding thin plate 220 (Brazing bonding step: S3330). Then, the resultant heat exchanger is taken out of the brazing furnace (not shown) (S3340).

Thereafter, a finishing and cleaning step (S3400) is carried out in order to trim the bonding thin plate 220 after the bonding step (S3300).

Therefore, comparing with the prior invention, the bonding process and the like is embodied in the same way, excepting the manufacturing of the metal plate 20 and the insulation panel 31, 320, thereby employ the existing production facilities without adding any separate facility. Thus, a heat exchanger having a good insulation performance can be provided, while omitting the construction and manufacturing process for a separate casing, insulation layer, or the like.

[Eighth embodiment]

Any one of the above manufacturing steps may further comprise a step of coating and/or forming and/or injecting a getter material on the inner diameter of the insulation hole 22 and/or the depression 311 of the insulation panel 310, 320, in order to execute a vacuum state more effectively.

In a common vacuum technique, only a vacuum pump is used and thus a desired degree of vacuum cannot be easily achieved, thereby causing many technical problems to be solved and resulting in a high cost.

The getter material is divided into a contact getter which is in a solid state and has

a strong adsorptive property and a dispersion getter which is in a gas state and has a strong compounding action. This getter includes an active carbon, barium, zirconium, and red phosphor. One or more getter selected from these materials are made into a paste or powder form of contact getter, which is coated or formed, or a gas state of dispersion getter may be injected additionally.

The process for coating the getter material, etc. is well known to those skilled in the art and thus details thereon will be described here.

Industrial Applicability

As described above, according to a micro heat exchanger and a manufacturing method thereof, an alternate stacking of bonding thin plates enables the brazing bonding at a time. Also, the micro channel containing face of the metal plate is faced downwardly and thus the melt of the bonding thin plate is not introduced into the micro channel, thereby guaranteeing precision and bonding the boundary area of the micro channels without any additional process.

In this way, since the boundary area of the micro channel is bonded, the heat resistance and pressure resistance of each flow passage formed by the micro channel can be maximized.

In addition, the metal plates are stacked such that the micro channel therein is crossed with each other, thus providing a higher efficiency for heat exchanging.

Furthermore, a heat exchanger having a good insulation efficiency can be provided, without necessity of a separate casing and insulation layer processing. The weight and volume of the heat exchanger can be reduced and the generation of radiant heat can be suppressed. The durability of external devices is not deteriorated.

In addition, it can be easily fabricated, the defective proportion is reduced, and the insulation efficiency is significantly improved to thereby enhance the heat exchanging efficiency. One or more insulation holes having a desired shape are punched in certain intervals in an area where a plurality of metal plates are faced with each other and then the metal plates are bonded through a brazing process, so that an insulation space is formed by means of the insulation hole. The insulation space can be vacuumed to thereby prevent the heat from being transmitted into the outer periphery of the metal plate.

Also, the insulation hole is formed through the metal plate in a shape and pattern so as not to seriously reduce the strength of the metal plate. The waste heat can be prevented from being conducted into the outer periphery of the metal plate from the heat-exchanging area including the micro channels. A separate insulation panel is inserted between the manifolds and between the metal plates and bonded by brazing, thus suppressing the heat transfer towards the manifold.

In particular, the performance of a heat exchanger used for fuel cells, which stand in the spotlight as a power supply for notebook computers, is not degrade, and also the heat exchanger can be further miniaturized.

While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by the embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.

What Is Claimed Is:

1. A micro heat exchanger comprising:

(a) a heat exchanging portion including a plurality of metal plates stacked and bonded to one another, the metal plate having a plurality of micro channels formed in parallel on the metal plate for flowing a first fluid, a supply channel and a discharge channel for supplying and discharging a fluid to and from each micro channel, a first connection hole connected to the supply channel and the discharge channel respectively and formed on the metal plate in such a way as to pass through, and a second connection hole for supply and discharging a second fluid; and

(b) a manifold including a fixing plate bonded symmetrically to upper and lower sides of the heat-exchanging portion and a pipe formed in the fixing plate in such a way as to pass through the fixing plate so as to be fluid–communicatively connected with the first connection hole and the second connection hole such that the first and second fluid are supplied and discharged respectively,

(c) wherein the bonding between the metal plates, the heat-exchanging portion and the fixing plate is performed by inserting a bonding thin plate in between and carrying out a brazing process.

2. The heat exchanger according to claim 1, wherein the heat-exchanging portion is formed through an alternate stacking and bonding in such a manner that the first connection hole through the metal plate and the second connection hole through the adjacent metal plate are fluid-communicated with each other and the micro channels on the neighboring metal plates are crossed at a certain desired angle.

3. The heat exchanger according to claim 2, wherein the supply channel and the discharge channel further includes a distribution channel formed on the metal plate so as to be branched off and flowed together correspondingly to the micro channel.

4. The heat exchanger according to claim 1 or 2, wherein the heat-exchanging portion is further provided with an insulation space formed by stacking the metal plates, which are further provided with one or more insulation hole formed in such a way as to pass through a desired area of the periphery of the micro channel.

5. The heat exchanger according to claim 4, wherein an insulation panel is inserted between the manifold and the heat-exchanging portion and bonded through a brazing process, the insulation panel including a through-hole fluid-communicated with the pipe of each manifold.

6. The heat exchanger according to claim 5, wherein the insulation panel is provided with one or more depressions on the micro channel forming direction.

7. The heat exchanger according to claim 4 or 6, wherein the insulation space or the depression is vacuumed by means of a vacuuming process during the brazing bonding process.

8. The heat exchanger according to claim 7, further comprising one or more vacuum port passing through integrally the insulation panel and another manifold stacked and combined therewith so as to be fluid-communicated with the depression and the insulation space.

9 A method of manufacturing a micro heat exchanger, the method comprising steps of:

(a) preparing a metal plate having a fluid supply channel and a fluid discharge channel, a plurality of parallel micro channels, and first and second connection holes connected respectively with the supply channel and the discharge channel;

(b) forming a heat-exchanging portion by stacking and bonding the metal plates with a bonding thin plate inserted in between, the micro channel facing one direction;

(c) forming each manifold to be symmetrically bonded to upper and lower sides of the heat-exchanging portion, the manifold having a fixing plate to which each pipe is temporarily bonded so as to be fluid-communicated with the first and second connection holes;

(d) coating a paste bonding agent near the connection area of each pipe to each fixing plate;

(e) forming an assembly by assembling the heat-exchanging portion, each fixing plate and each manifold between a fixing jig and a mobile jig moving relative to the fixing jig, correspondingly to the fluid supply and discharge path, and placing a relatively small load weight on top of the mobile jig so as to exert a uniform load to the metal plate of the heat-exchanging portion;

(f) placing each assembly in a brazing furnace, and heating the assembly above the melting temperature of the bonding thin plate and the bonding agent to thereby perform a bonding; and

(g) removing the fixing jig, the mobile jig and the load weight after taking the assembly out of the brazing furnace.

10. The method according to claim 9, wherein the step (b) further comprises a step of alternately stacking the metal plates in such a manner that a first connection hole of the metal plate is fluid-communicatively connected with a second connection hole of a neighboring metal plate and a micro channel of the metal plate is crossed with the micro channel of the neighboring metal plate at a certain desired angle.

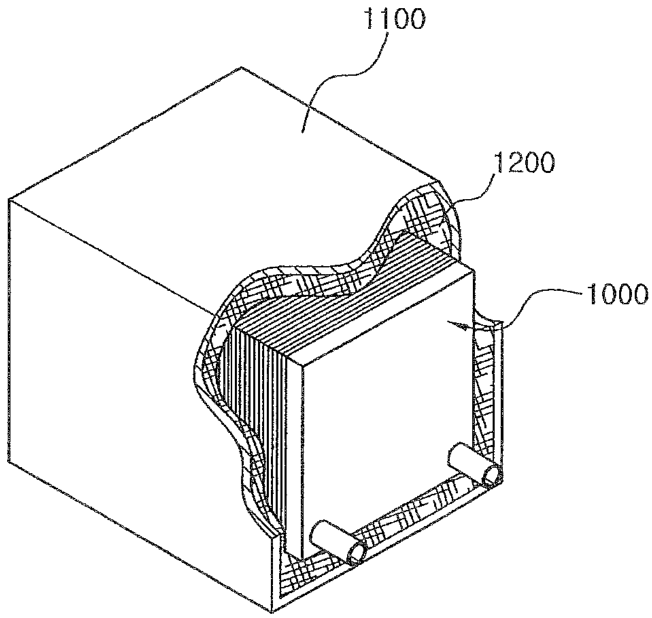
11. The method according to claim 10, wherein the step (a) further comprises a step of forming a distribution channel on the supply channel and the discharge channel such that the micro channel and the first connection hole are fluid-communicated with each other, and branched off and flowed together respectively.

12. The method according to claim 10, wherein the step (b) further comprises a step of disposing the metal plate in such a way that the micro channel containing face thereof faces downwards.

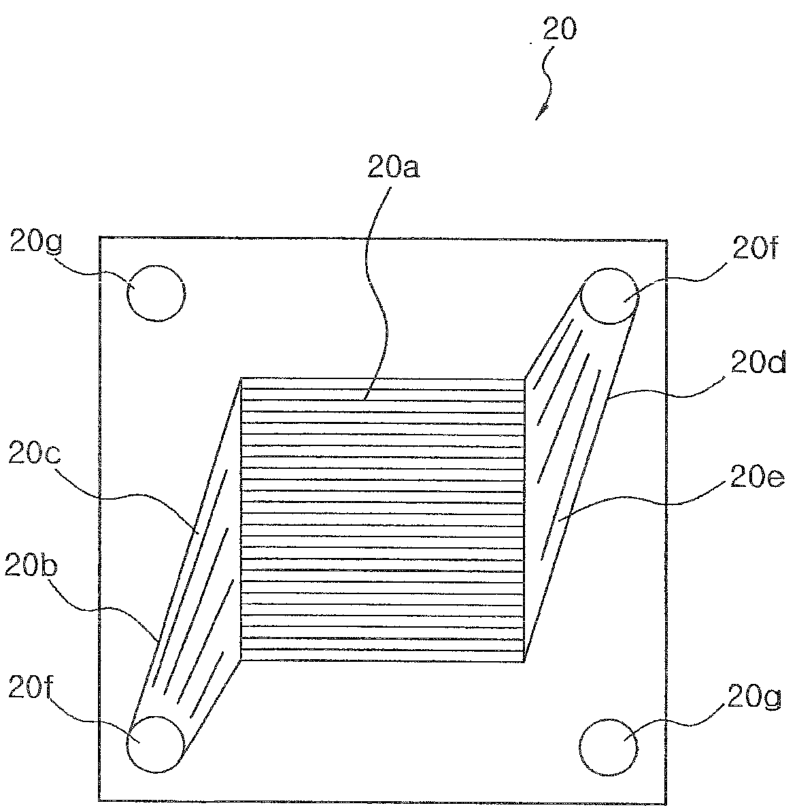
13. The method according to claim 10, wherein the step (a) further comprises a step of punching an insulation hole of same shape in a same place.

14. The method according to claim 10, wherein the step (b) further comprises a step of stacking an insulation panel between the manifold and the metal plate, and inserting and stacking a bonding thin plate in between.

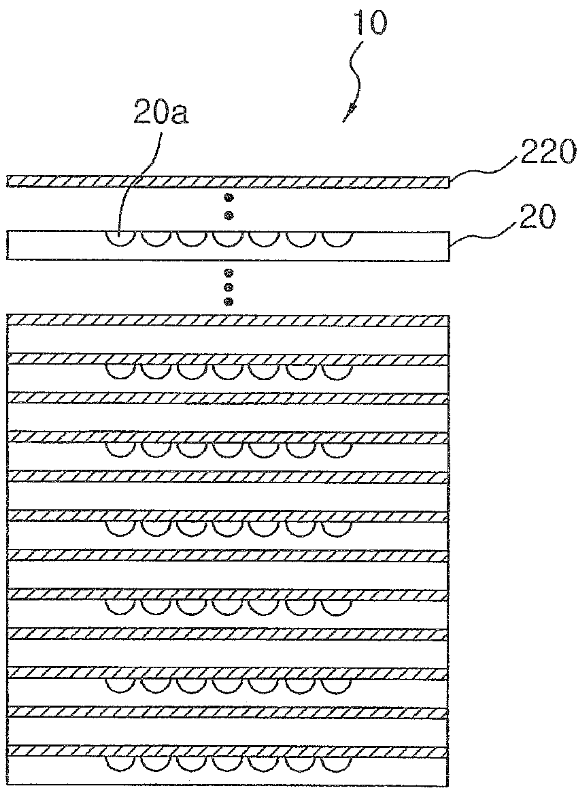
【Figure 1】



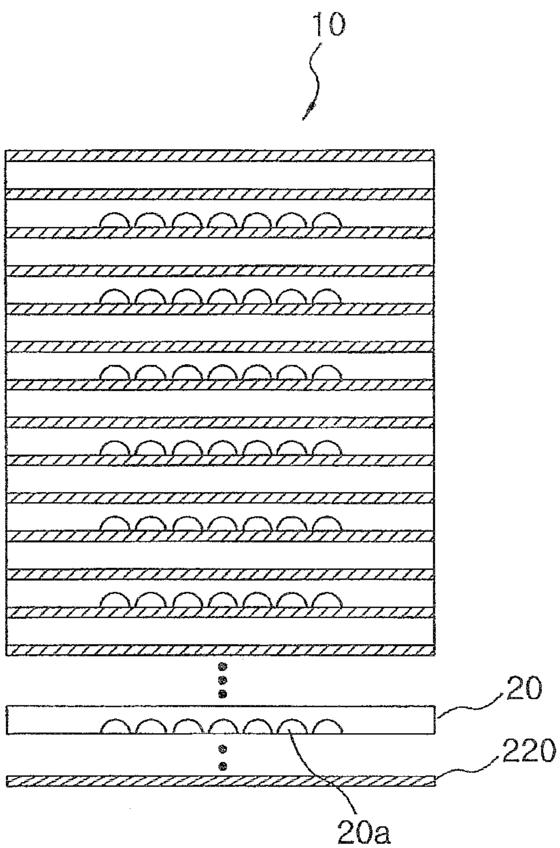
【Figure 2】



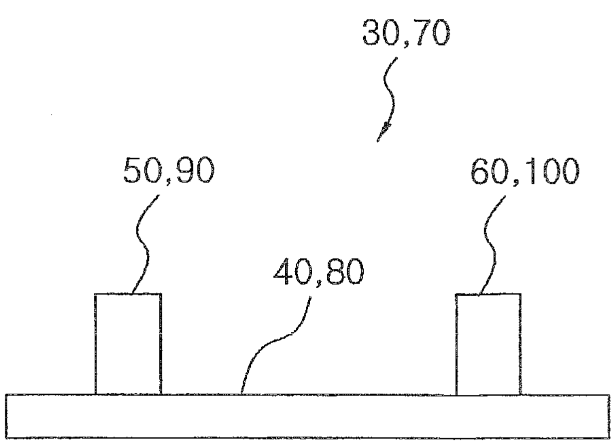
【Figure 3】



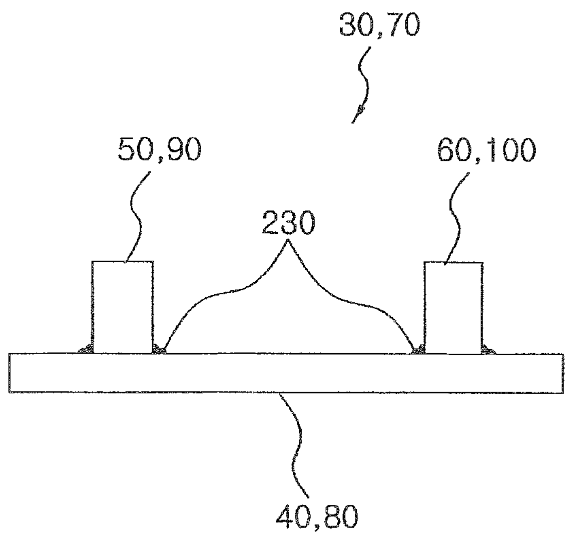
【Figure 4】



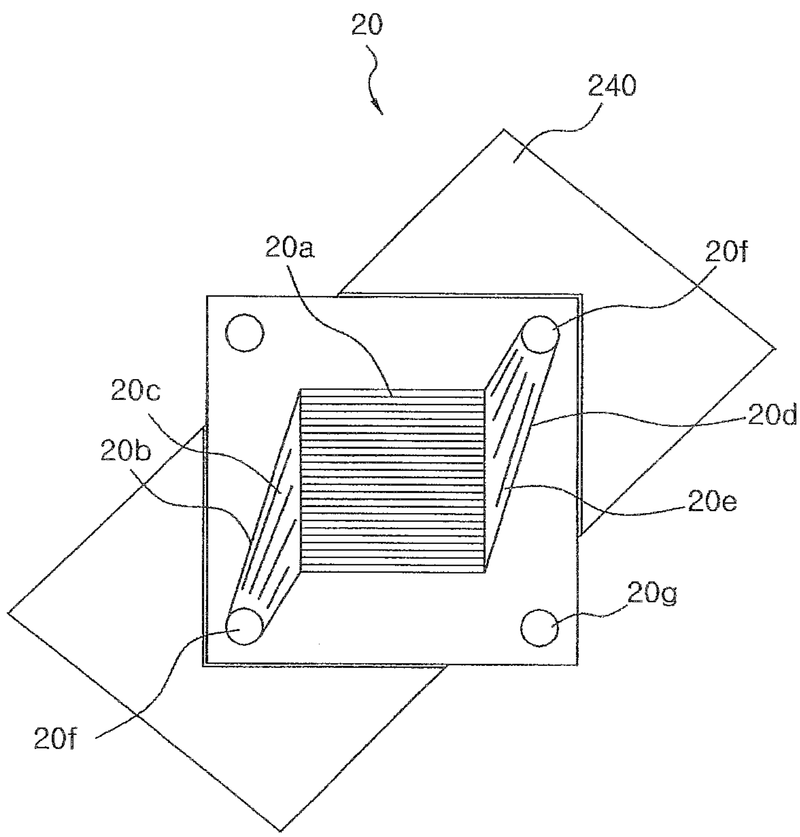
【Figure 5】



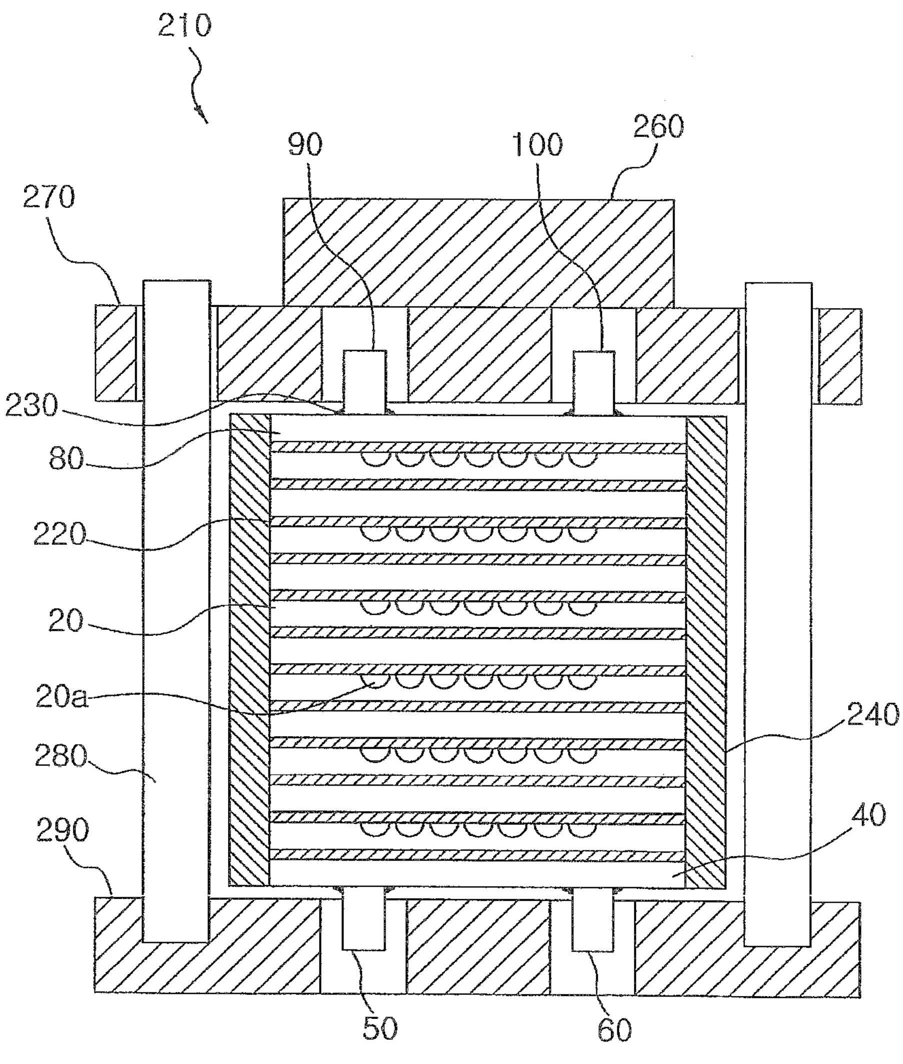
【Figure 6】



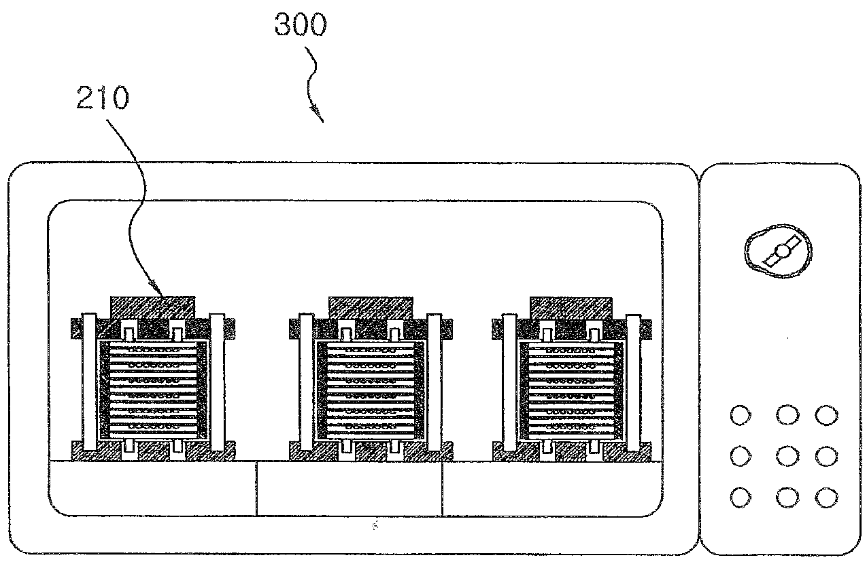
【Figure 7】



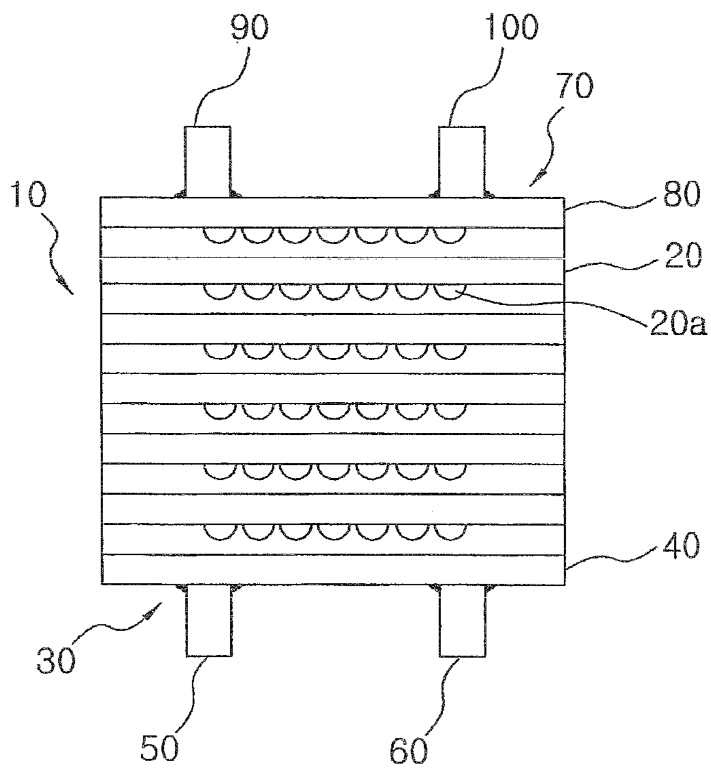
【Figure 8】



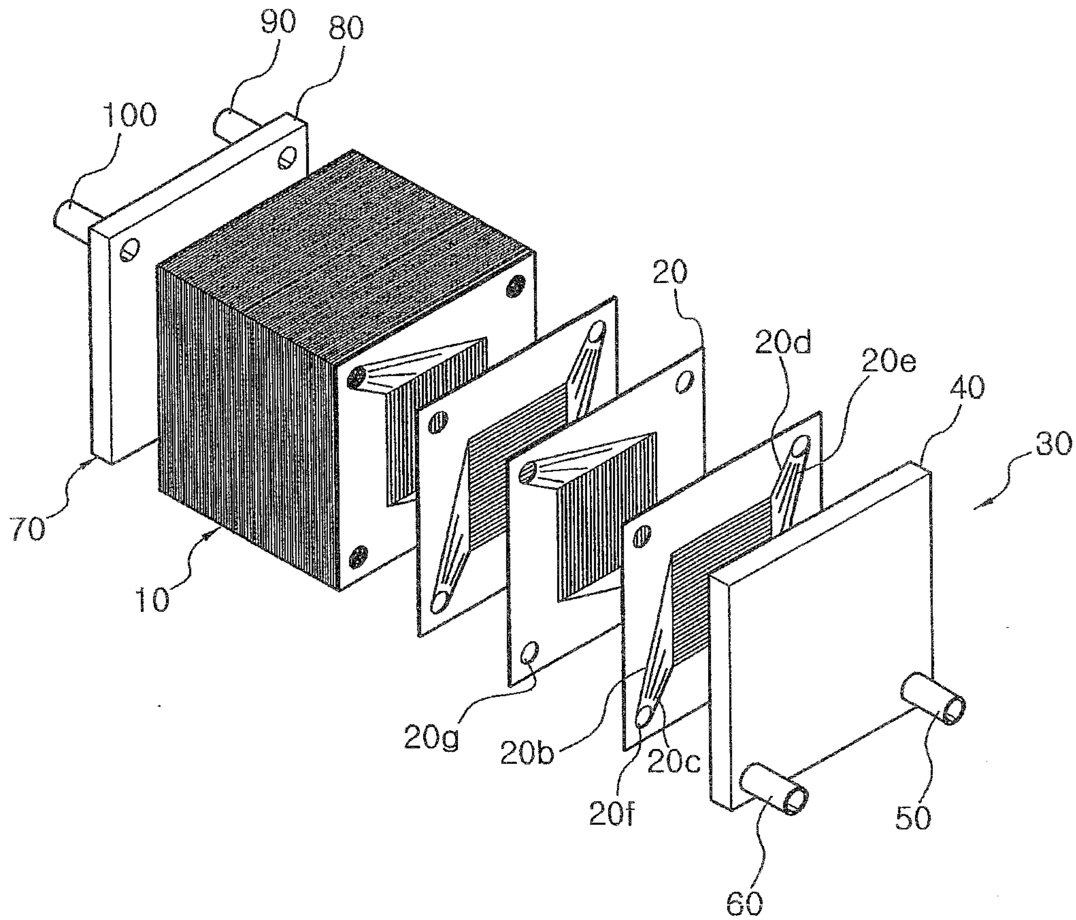
【Figure 9】



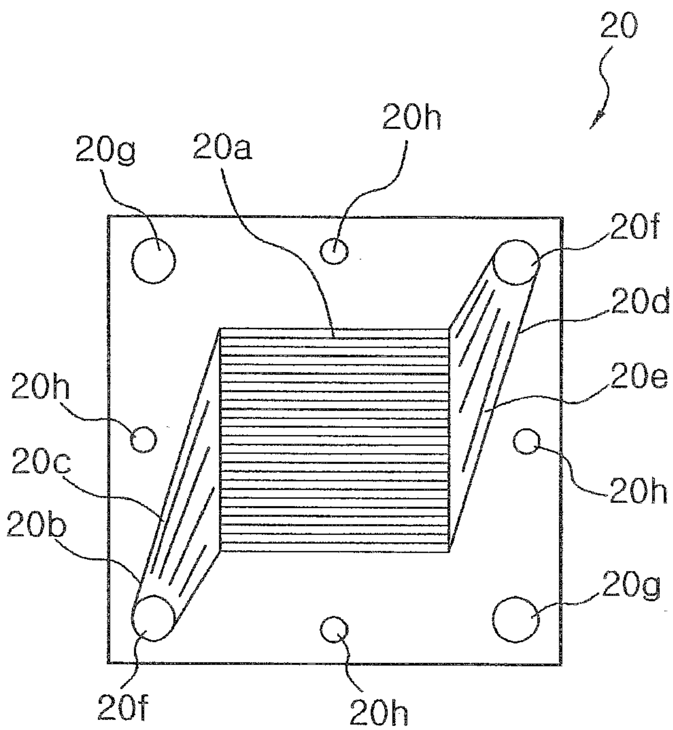
【Figure 10】



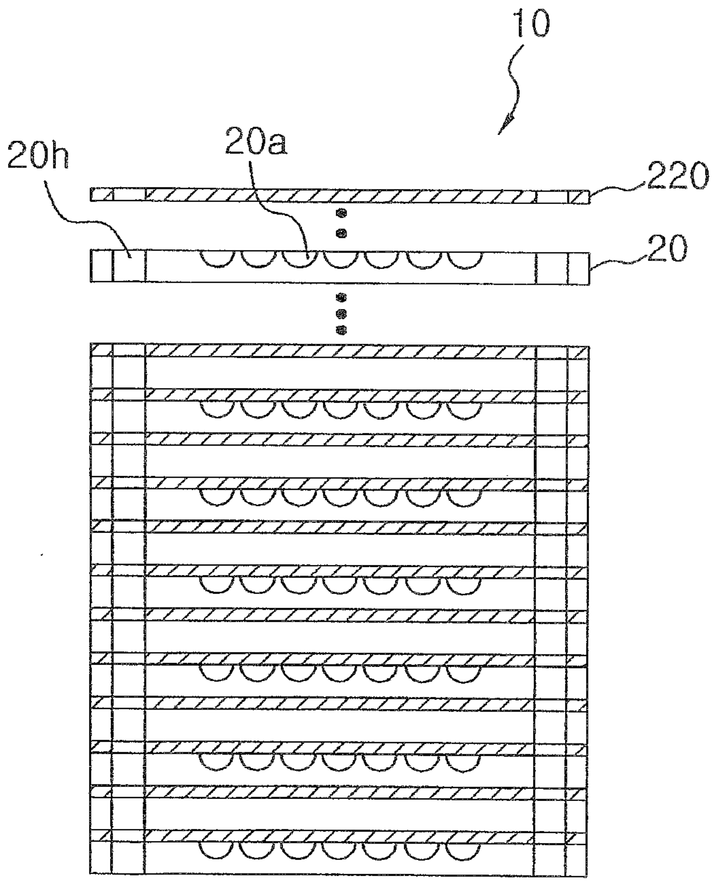
【Figure 11】



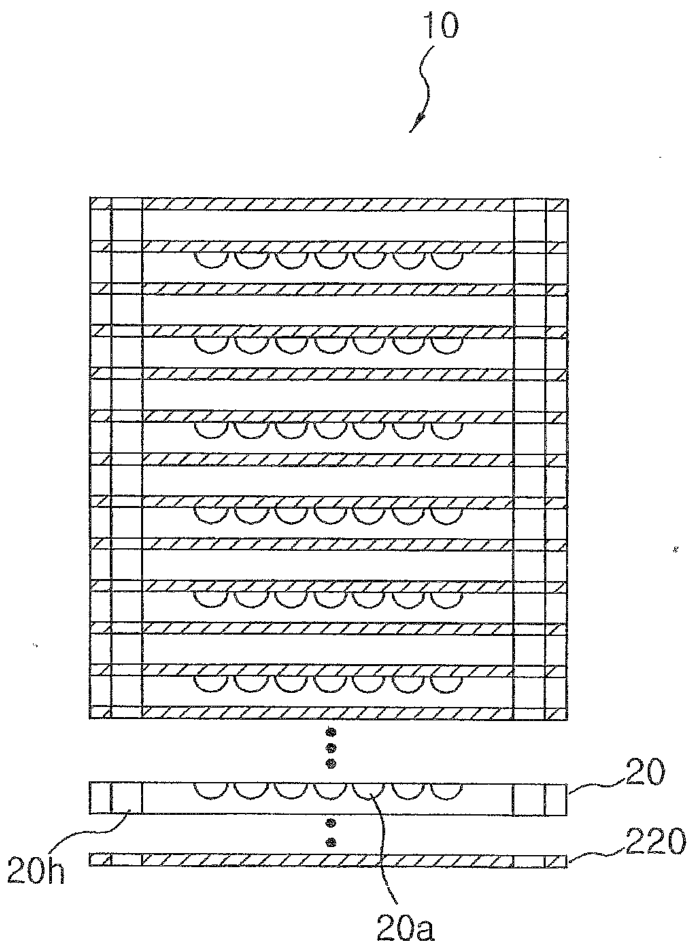
【Figure 12】



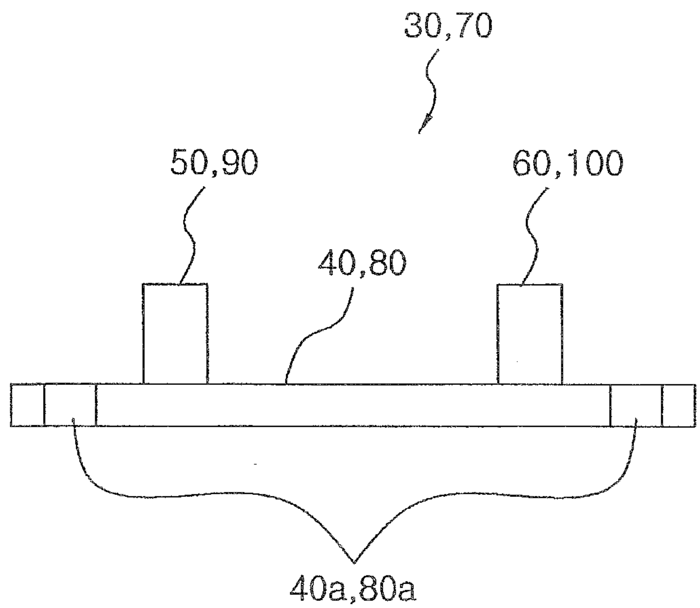
【Figure 13】



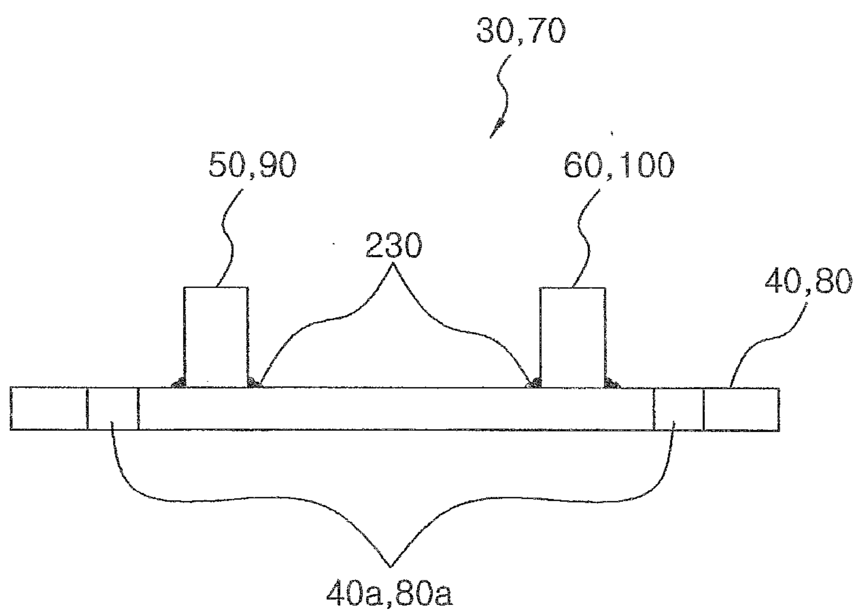
【Figure 14】



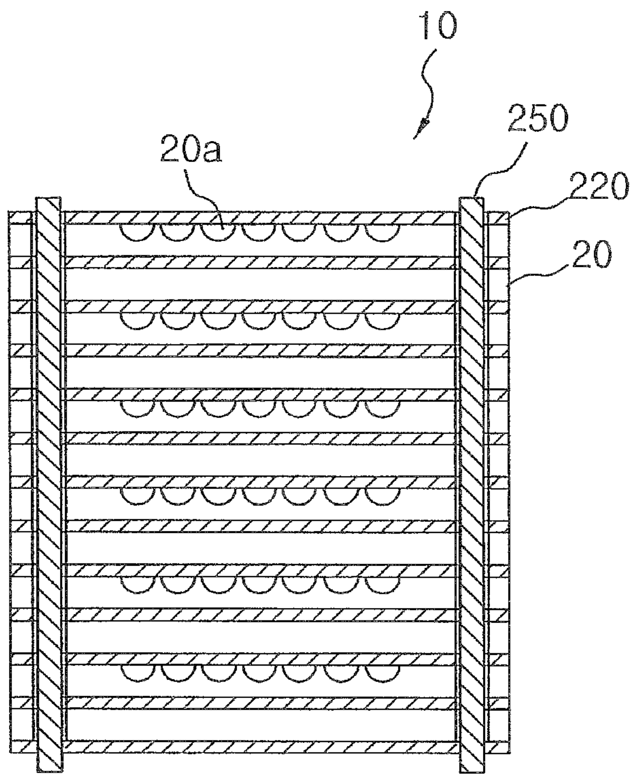
【Figure 15】



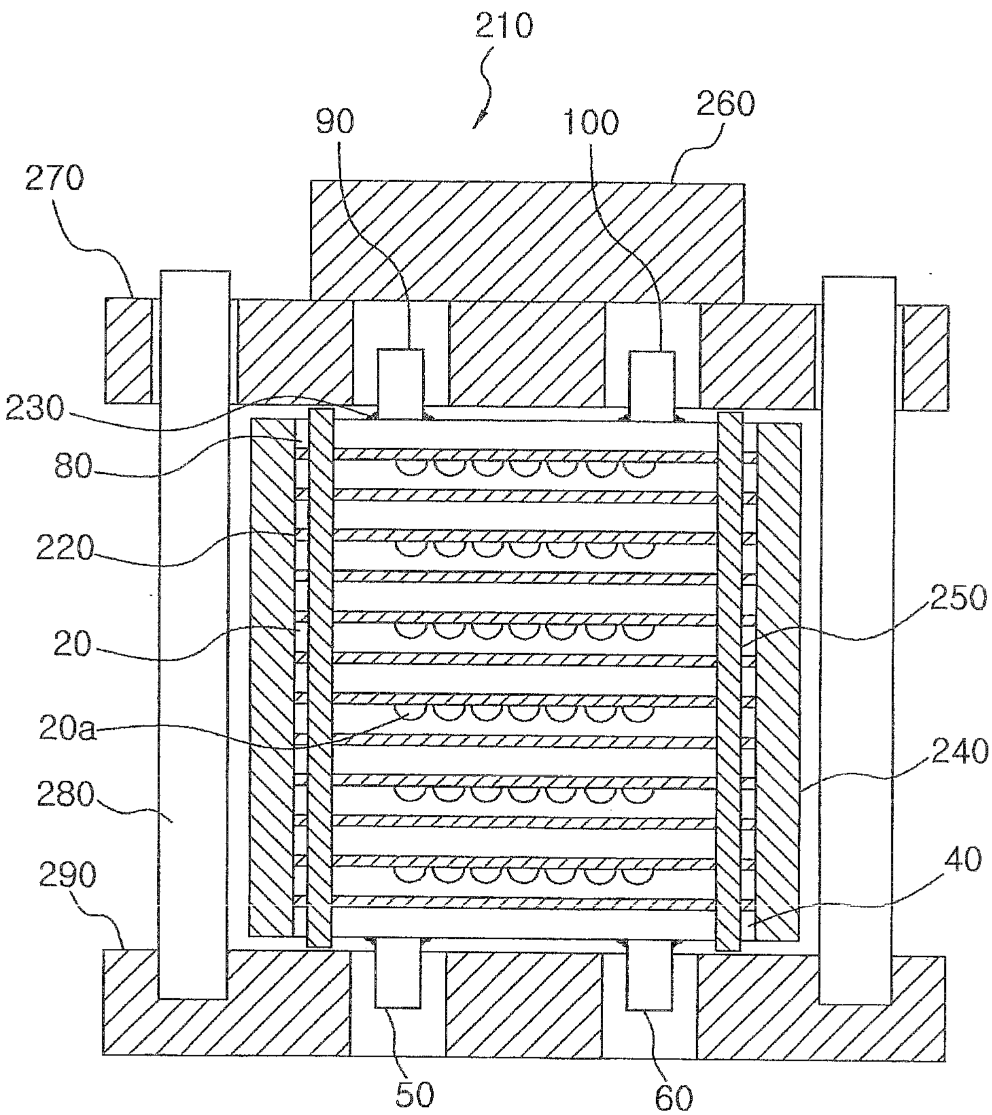
【Figure 16】



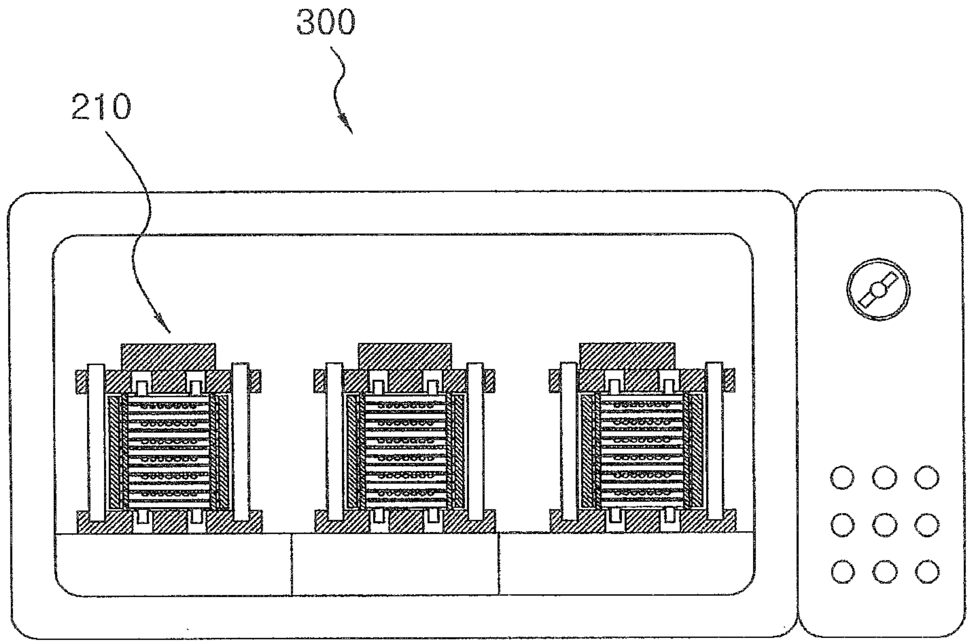
【Figure 17】



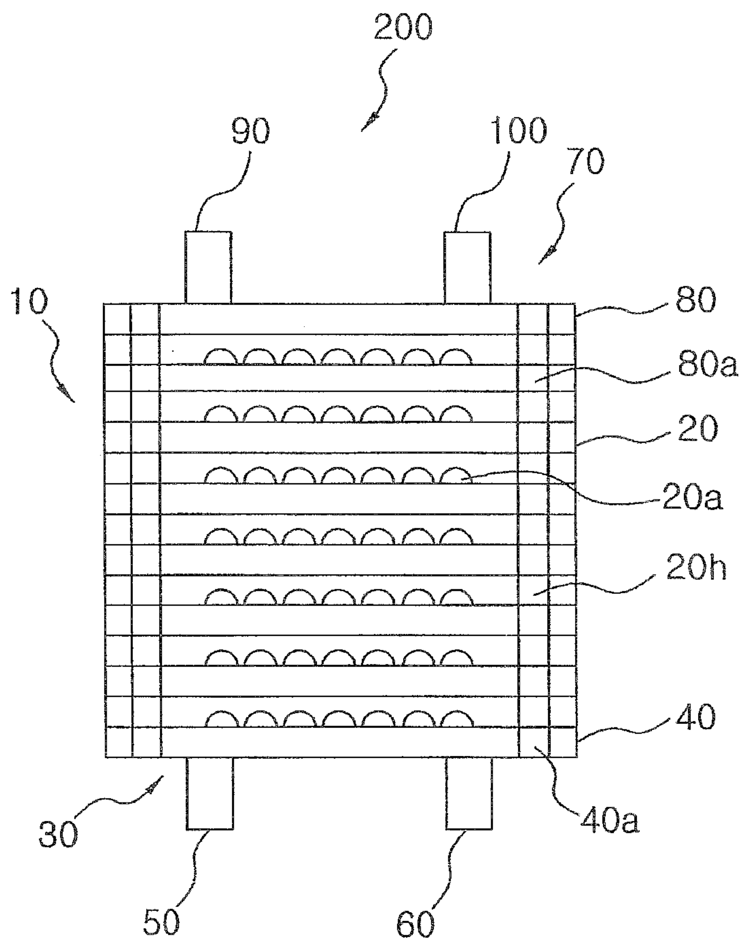
【Figure 18】



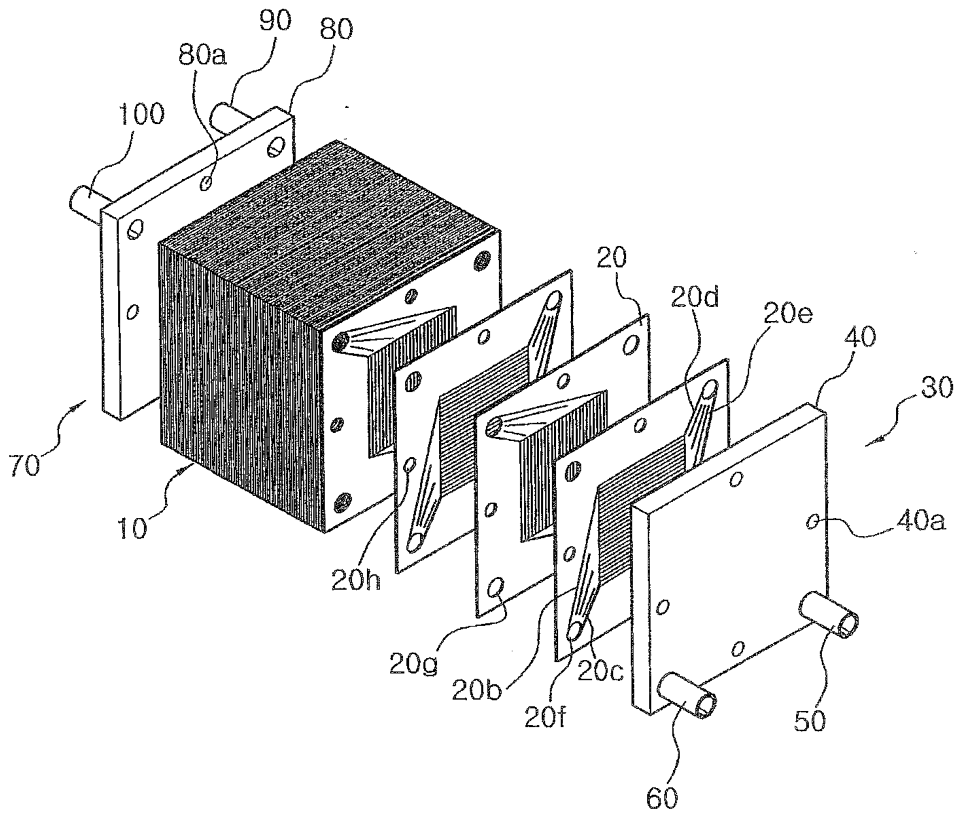
【Figure 19】



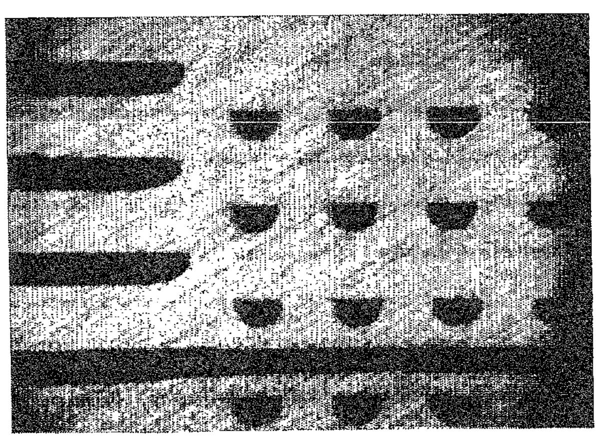
【Figure 20】



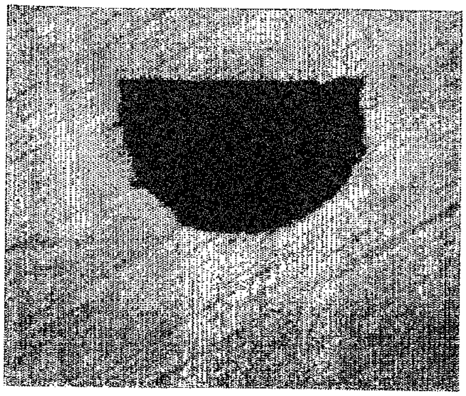
[Fig. 21]



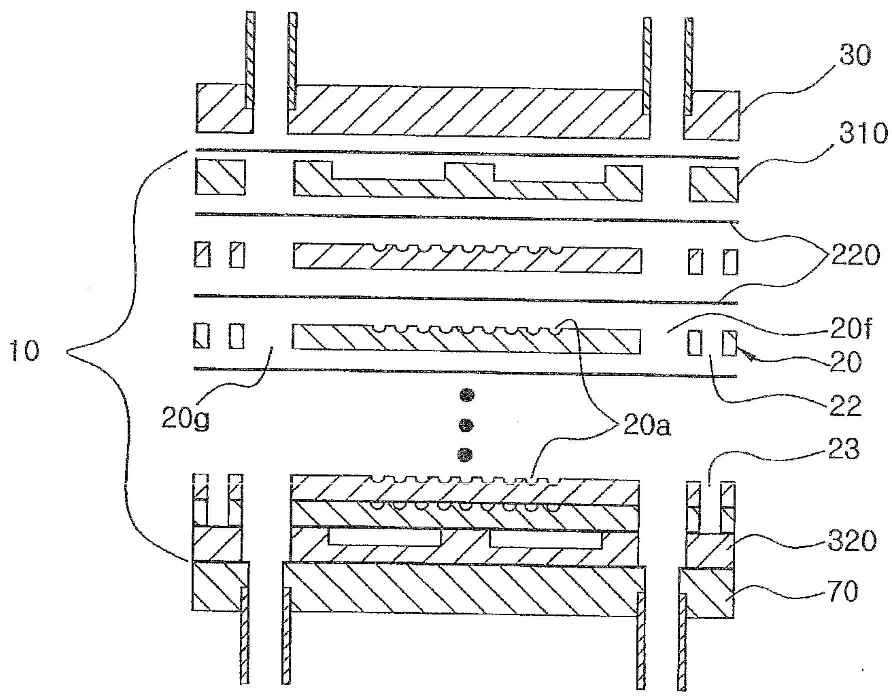
[Fig. 22]



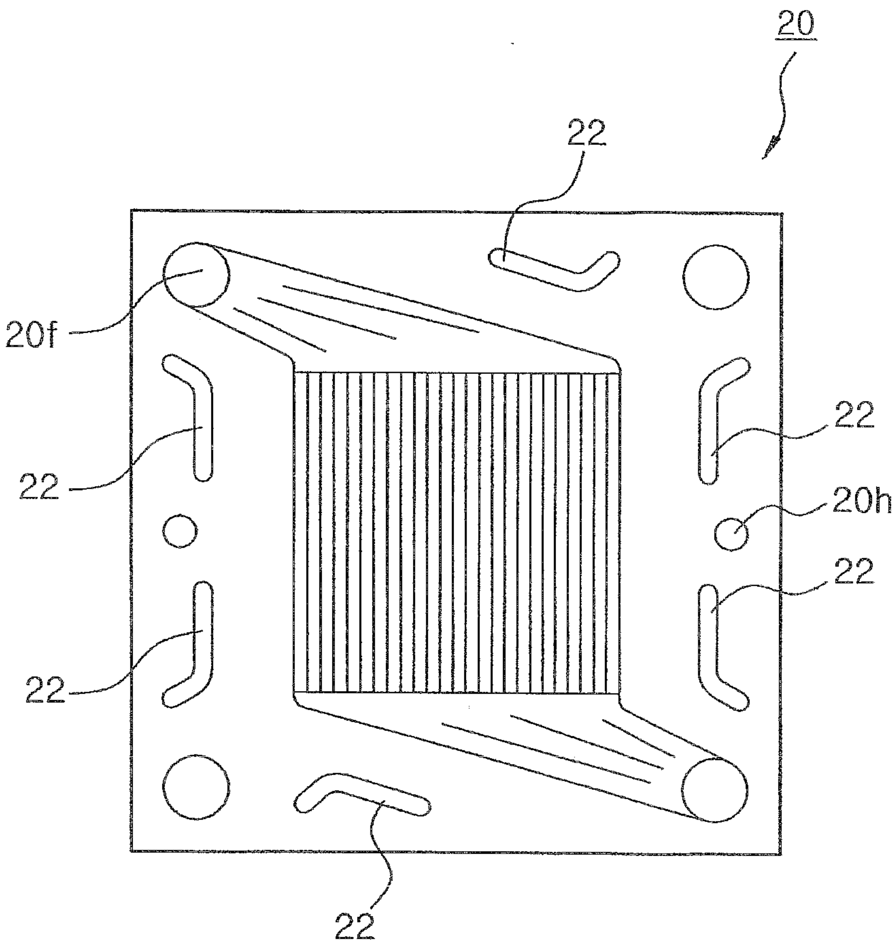
[Fig. 23]



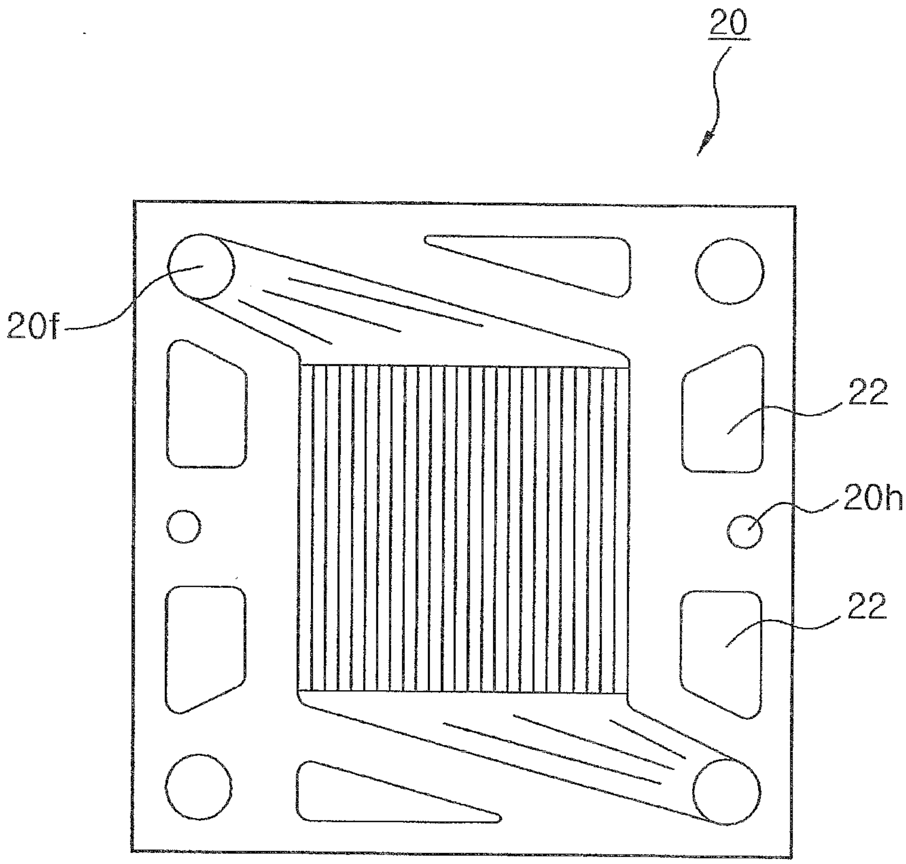
[Fig. 24]



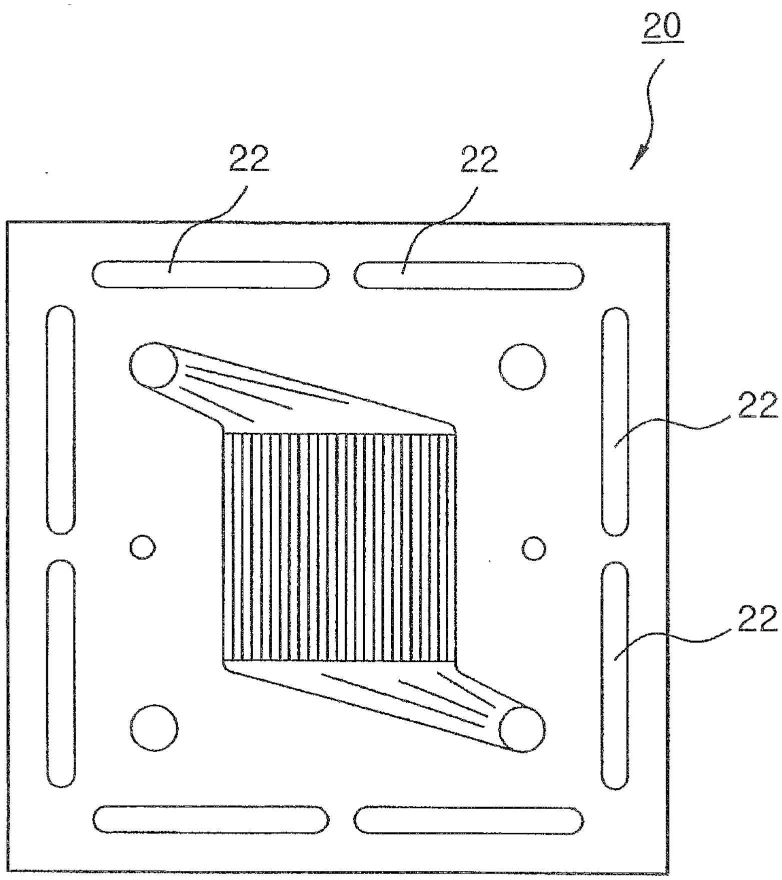
【Figure 25】



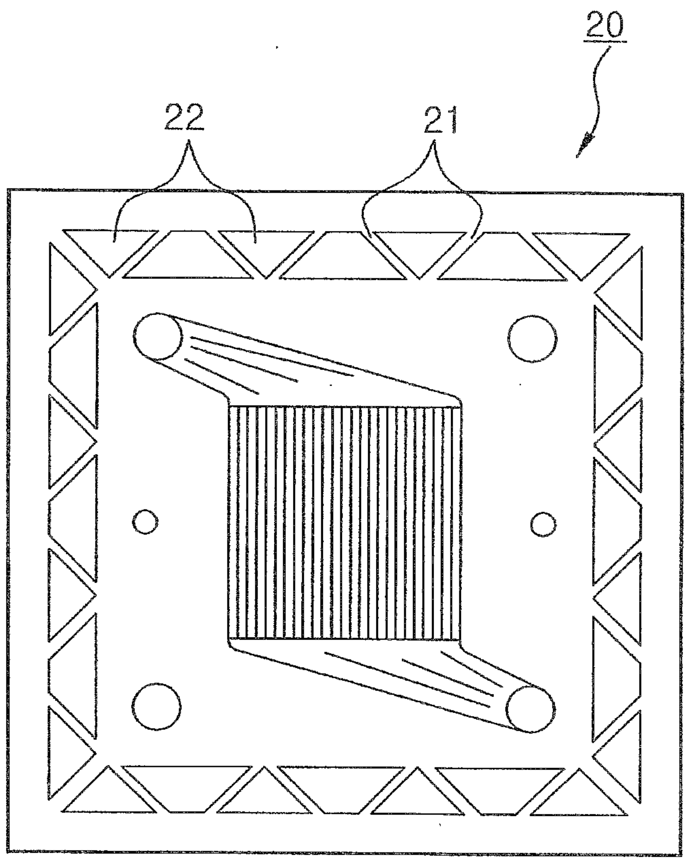
【Figure 26】



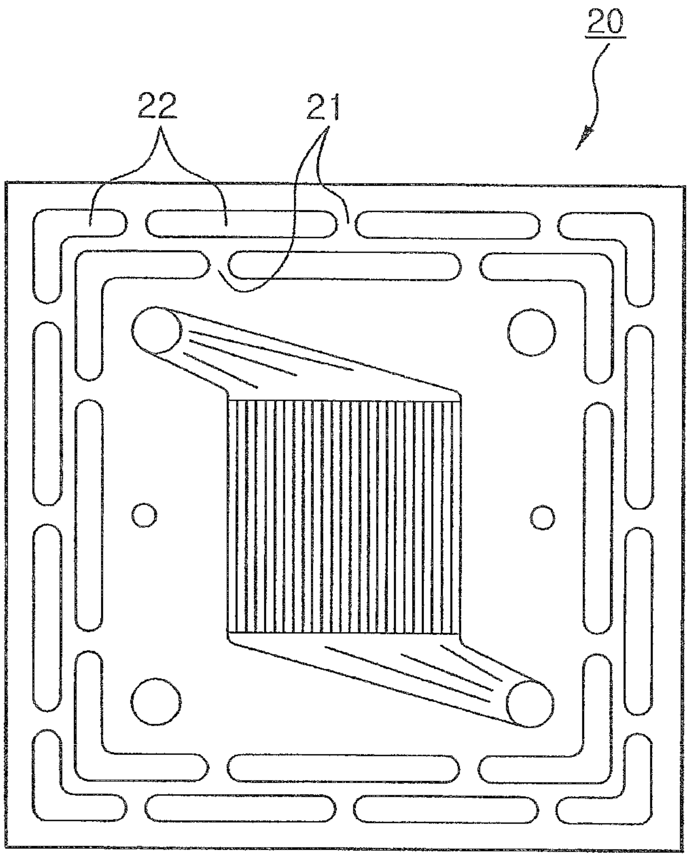
【Figure 27】



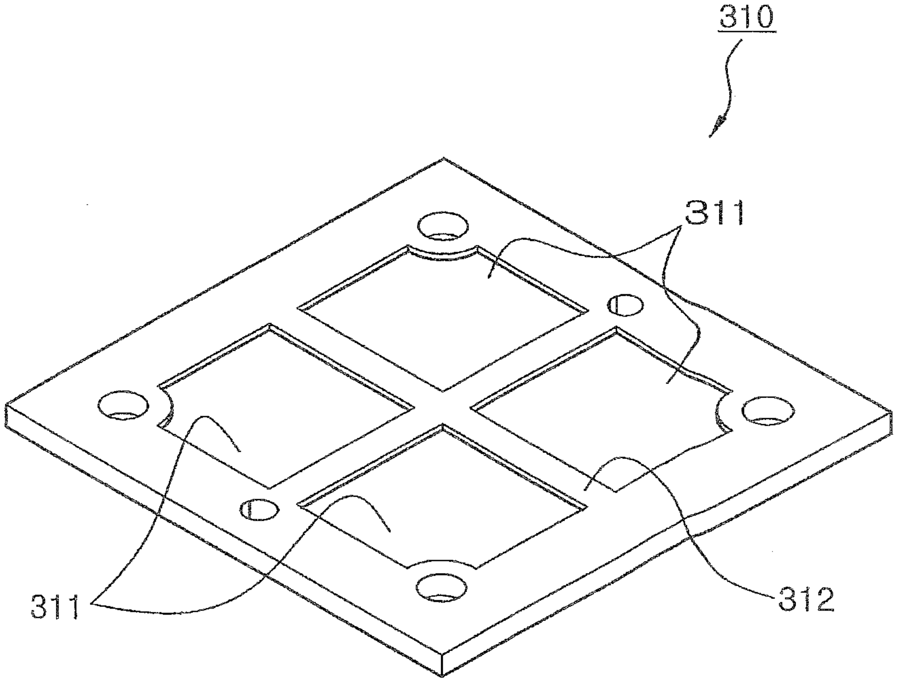
【Figure 28】



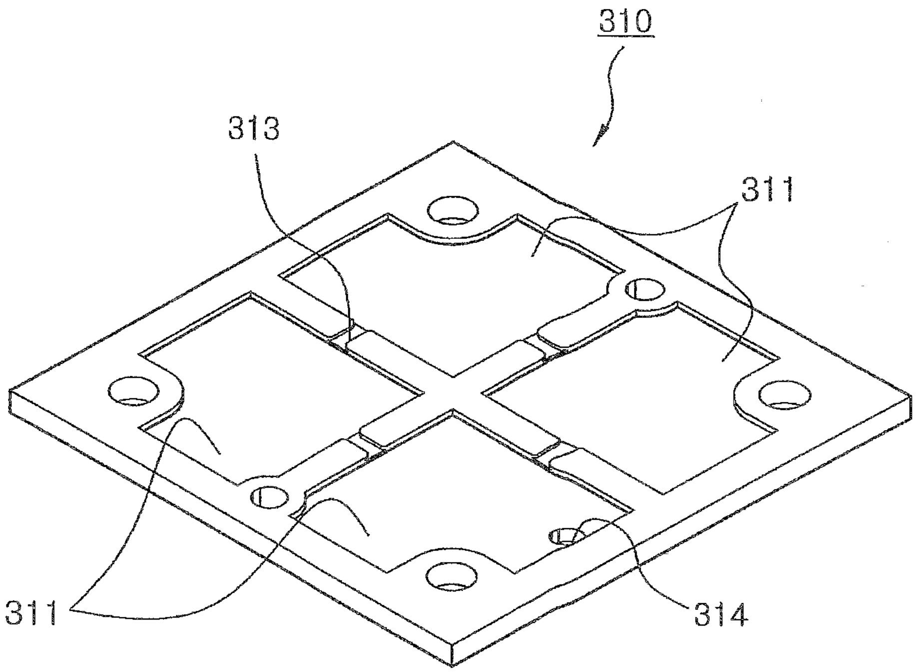
【Figure 29】



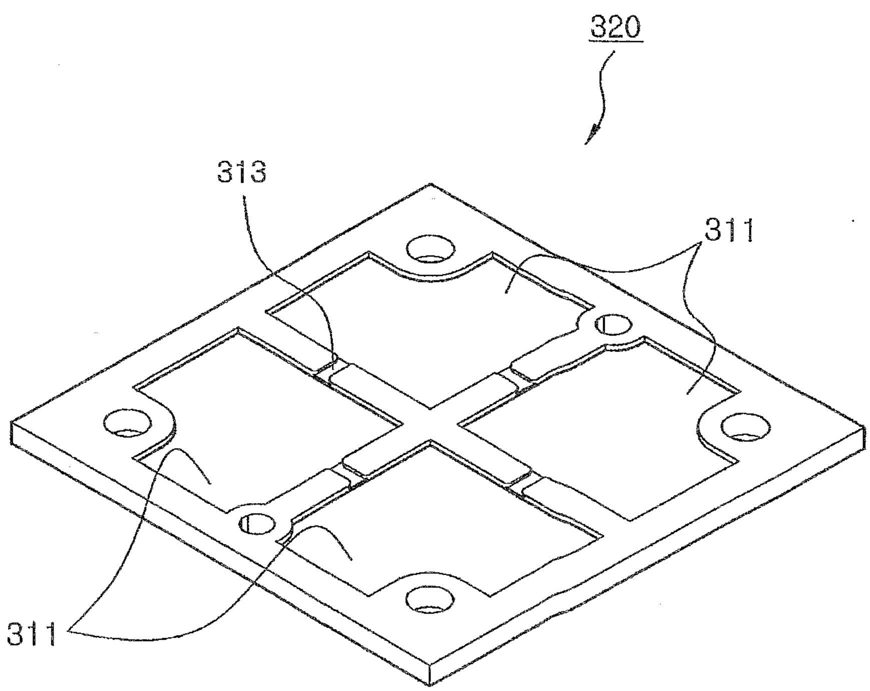
【Figure 30】



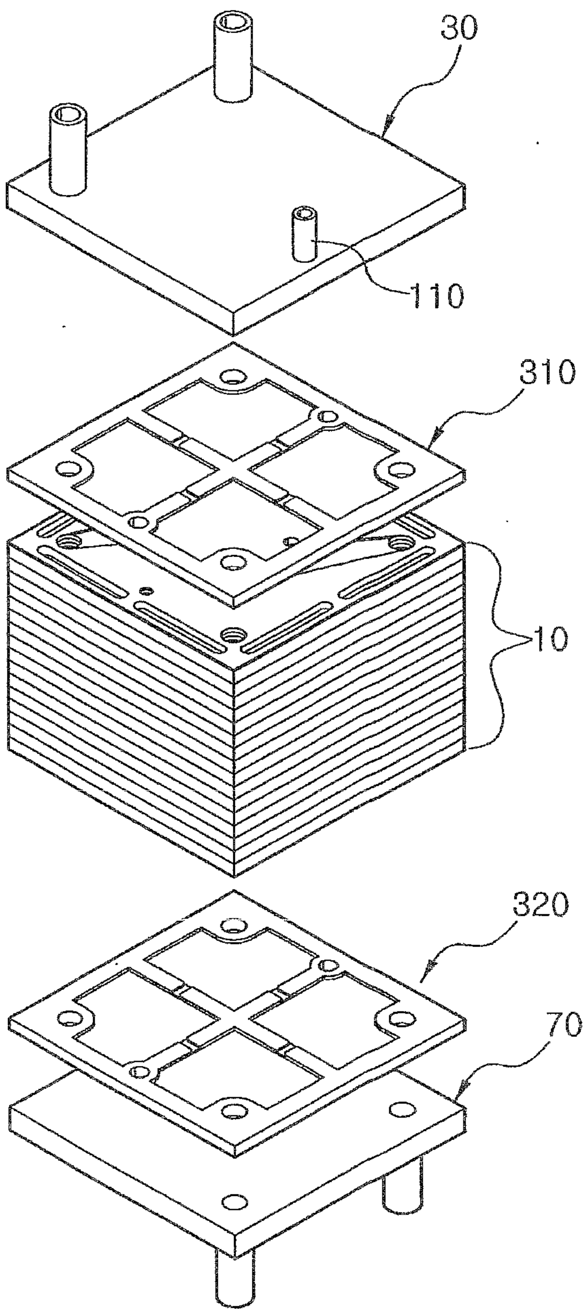
【Figure 31】



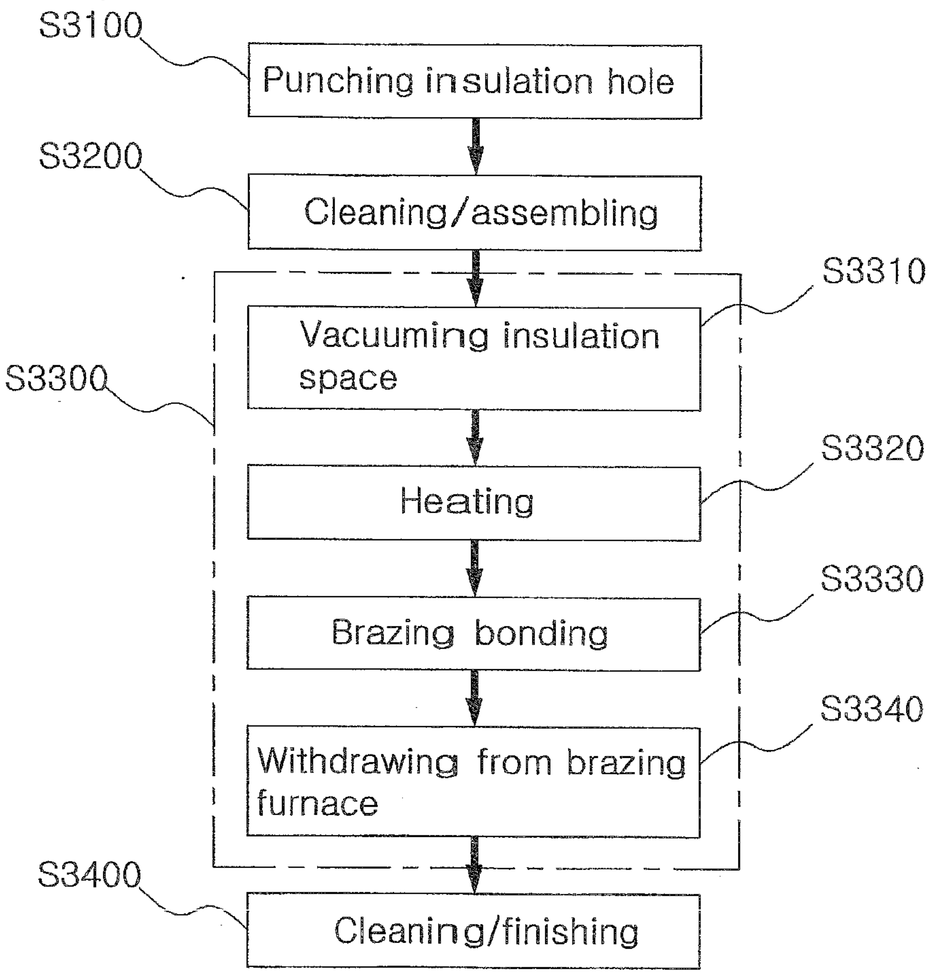
【Figure 32】



【Figure 33】



【Figure 34】


S3100
Punching insulation hole
S3200
Cleaning/assembling
S3310
Vacuuming insulation space
S3300
S3320
Heating
S3330
Brazing bonding
S3340
Withdrawing from brazing furnace
S3400
Cleaning/finishing

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2005/000467

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 F28D 9/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7 F28D, F28F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

KR, JP : classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,815,534 A (Raymond F. Fuerschbach) 28.05.1989 see the whole document	1 - 3, 9 - 13
Y	US 4,347,896 A (Irwin E. Rosman et al.) 07.09.1982 see the whole document	1 - 3, 9 - 13
Y	US 4,516,632 A (Gregory W. Swift et al.) 14.05.1985 see the whole document	9 - 13
A	JP 2000-161889 A (16.06.2000) see the whole document	1 - 14

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 JUNE 2005 (15.06.2005)	**16 JUNE 2005 (16.06.2005)**

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701,
Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

KIM, Eun Rae

Telephone No. 82-42-481-5518

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2005/000467

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 04815534	1989.05.28	CA 1276009 A1	1990.11.06
US 04347896	1982.09.07	US 4503908 A	1985.03.12
		US 4523638 A	1985.06.18
		US 4535840 A	1985.08.20
		US 4749032 A	1988.06.07
US 4516632	1985.05.14	NONE	
JP 12161889	2000.06.16	CN 1328632 A	2001.12.26
		CN 1131989 C	2003.12.24
		EP 1136782 A1	2001.09.26
		EP 1136782 A4	2003.03.19
		KR 100436908 B1	2004.06.23
		TW 493059 B	2002.07.01
		TW 493059 A	2002.07.01
		WO 200031487 A1	2000.06.02